PEER REVIEW DRAFT

National Survey of Lead and Allergens in Housing

FINAL REPORT

Volume I: Analysis of Lead Hazards

Revision 5.3

Prepared for:

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EXECUTIVE SUMMARY

The National Survey of Lead and Allergens in Housing (referred to as the National Survey) was conducted under the sponsorship of the Department of Housing and Urban Development (HUD) and the National Institute of Environmental Health Sciences (NIEHS) to assess children's potential household exposure to lead and allergens The National Survey measured the levels of lead in dust, soil, and paint, the prevalence of hazardous levels of lead, and levels and patterns of various indoor allergens in dust in homes. Volume I includes the findings for lead hazards, and describes lead levels in dust, soil, and paint in the nation's housing by age, type, geographical location, and exposed populations. This Executive Summary refers to the standards of HUD's new "Lead Safe Housing Rule" on Federally-owned and -assisted housing[1]. Appendix A compares the National Survey findings using these current standards with the guidance provided in HUD's 1995 *Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing* (*"Guidelines")*. The definition of lead-based paint is the same for both (1.0 mg/cm^2), while the definition of lead-based paint hazard has changed in accordance with advances in scientific understanding and statutory changes.

Results: Extent of Lead-Based Paint and Lead-Based Paint Hazards in Housing

An estimated 38 million[2] homes (40 percent of all homes) in the United States have lead-based paint somewhere in the building. Of these, 20 million homes have lead-based paint present on both interior and exterior surfaces, 9 million homes have lead-based paint only on the interior, and another 9 million homes have lead-based paint only the exterior.

Although a large number of homes have lead-based paint, most of them have relatively small surface areas of it. The average home with lead-based paint has an estimated 259 square feet of interior lead-based paint and 996 square feet of exterior lead-based paint.

An estimated 25 million (26 percent) homes have significant lead-based paint hazards somewhere in the building or on the premises; this is similar to earlier HUD estimates of 24 million homes Based on the HUD Lead Safe Housing Rule, a home is said here to have a significant lead-based paint

[1] Title 24 of the Code of Federal Regulations, Part 35 was issued September 15, 1999 in Volume 64 of the Federal Register, pages 50140-50231, and is effective September 15, 2000. It implements sections 1012 and 1013 of the Residential Lead-Based Paint Hazard Reduction Act of 1992, which is Title X of the Housing and Community Development Act of 1992 (P.L. 102-550). A copy is available on the Internet at www.hud.gov/lea.

[2] The 95 percent confidence intervals for the estimates are presented in the main body of the report.

hazard if one or more of the following conditions exists: lead-based paint with deterioration larger than *de minimis* levels specified in the Lead Safe Housing Rule[3]; dust lead loadings at or above specified thresholds on floors or window sills[4] ; bare soil in children's play areas above specified thresholds; or more than 9 square feet of bare soil in the rest of the yard with lead concentrations at or above specified thresholds[5].

Of the 16.4 million homes with one or more children under age 6, an estimated 4.4 million (27 percent) have significant lead-based paint hazards. Of all 4.8 million homes with household incomes under $30,000 and one or more children under age 6, an estimated 1.4 million (29 percent) have significant lead-based paint hazards. Thus, one in four homes with young children among the residents have significant lead-based paint hazards. Table ES.1 summarizes these basic estimates of the prevalence of lead-based paint and significant lead-based paint hazards.

Table ES.1 Summary Estimates of Prevalence of Lead-Based Paint and Lead-Based Paint Hazards

Housing Unit Characteristic[1]	Number of Housing Units (millions)	Number of Housing Units with Lead-Based Paint (millions)	Number of Housing Units with Significant Lead-Based Paint hazards (millions)
Total housing units	95.7	37.9	25.2
One or more children under age 6	16.4	5.3	4.4
One or more children under age 6, less than $30,000/year household income	4.8	1.4	1.4

[1] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

Of the 25 million homes with significant lead-based paint hazards, an estimated 16 million have interior dust lead hazards, 14 million have deteriorated lead-based paint at or above *de minimis* levels and 6 million have soil lead hazards.

[3] The *de minimis* levels for LBP deterioration are in Section 35.1350(d) of the Lead Safe Housing R rule. These levels are: deterioration of more than 20 square feet (exterior) or 2 square feet (interior) of LBP on large surface area components (walls, doors) or deterioration of to more than 10% of the total surface area of interior small surface area components types (window sills, baseboards, trim). These are the same levels used in the U.S. Environmental Protection Agency's lead hazard standards rule implementing the Toxic Substance Control Act's section 403.

[4] The floor and window sill dust lead loading thresholds are dust on floors with greater than or equal to 40 $\mu g/ft^2$ lead and dust on window sills with greater than or equal to 250 $\mu g/ft^2$ lead. They are in the HUD Lead Safe Housing rule and in the EPA Rule *Identification of Dangerous Levels of Lead*; 40 CFR Part 745, January 5, 2001.

[5] The thresholds for bare, lead-contaminated soil are more than 9 square feet of bare soil with a lead concentration greater than or equal to 2,000 ppm lead, or 400 ppm for bare soil in an area frequented by a child under the age of 6 years. These thresholds are in the HUD Lead Safe Housing Rule. The EPA Rule *Identification of Dangerous Levels of Lead* has the same threshold for children's play areas, but a threshold of 1,200 ppm for the rest of the yard.

Dust lead levels above the Lead Safe Housing Rule's standards are associated with the presence of interior lead-based paint. An estimated 29 million homes have some interior lead-based paint, of which 39 percent have dust lead levels above the Lead Safe Housing Rule's standards. In contrast, only 6 percent of the 67 million homes without interior lead-based paint have dust levels above the Lead Safe Housing Rule's standards.

Soil lead levels above the Lead Safe Housing Rule's standards are associated with the presence of deteriorated lead-based paint. While 13 percent of the 14 million homes with deteriorated lead-based paint have lead in bare soil at or above 2,000 parts per million, only 2 percent of the 78 million homes without deteriorated lead-based paint have bare soil lead above this threshold.

Survey Design and Methodology

The principal lead-related purpose of the National Survey of Lead and Allergens in Housing was to develop a scientific description of the existing lead levels in paint, dust, and soil in the nation's housing. Additional objectives were to obtain data to: (1) estimate the number and percent of homes with dust and soil lead levels above selected thresholds; (2) identify sources of lead in dust in housing, e.g., paint and soil; (3) permit future analyses of lead hazard control strategies and costs, e.g., quantities of deteriorated painted surfaces; and (4) permit future analyses for regulation, policy, and guidance that minimize regulatory and program implementation burden.

The target population included approximately 96 million homes, out of the of the 112 million total homes in the nation, including single- and multi-family buildings and manufactured housing units, e.g., mobile homes and trailers. Homes built in all age categories were included. Vacant housing, group quarters, and hotels and motels were excluded for operational reasons. Housing where children were not permitted to live, e.g., elderly care facilities, were excluded because the primary interest was in children's exposure to lead. Thus, 16 million units out of 112 million total units were excluded from this survey.

The main field survey was conducted in 1998-1999, with an augmentation of the soil sampling in 2000. A nationally-representative sample of 1,984 homes was drawn from 75 clusters (each a metropolitan statistical area (MSA) or a cluster of counties) called *primary sampling units* (PSUs).[6] A total of 831 eligible homes were recruited and completed the survey.

[6] A PSU is a metropolitan statistical area (MSA) or a cluster of counties.

Four rooms were randomly selected for environmental sample collection and testing from each of four room types: kitchen, common living areas, bedrooms (preferably those occupied by children), and other rooms. In each of these four rooms floor, window sill, and window trough dust samples were collected, painted surfaces were measured for lead content, and the condition of painted surfaces was assessed. Outside the building, soil samples were taken and exterior painted surfaces were tested. A floor dust sample was collected in the interior common area of multi-family buildings.

Measurements of lead in paint were made by State- or EPA-certified lead-based paint inspectors using an XRF analyzer and a protocol based on the 1997 *Guidelines*' inspection procedure. The instrument model used does not require making substrate corrections, nor have an inconclusive range, both of which involve destructive sampling of painted surfaces. One XRF reading was made per painted component in each room, approximately in the center of a randomly selected quadrant of the total building component surface area.

Single wipe dust samples were collected by the technique described in ASTM E 1728-95.[7] Floor dust samples were collected in the center of the largest open floor area in the room. The floor samples in the major entrance and interior common area were collected approximately six inches away from the center of the doorway. One-square-foot templates were used for floor samples. Window sill and trough samples were collected from a random, openable window in each selected room. The entire area was wiped for window sill and trough samples (up to two square feet). All dust samples were analyzed by flame atomic absorption spectrophotometry, using the Environmental Protection Agency's (EPA's) SW-846 method 3050 digestion method and the American Industrial Hygiene Association's *Environmental Lead Laboratory Accreditation Program (*ELLAP*)* proficiency testing procedures.

Soil sampling was conducted in accordance with core sampling procedures described in the 1995 HUD *Guidelines*. Only the top one-half inch of each soil core, i.e., that portion most accessible to children, was included in the sample. Where necessary, grass or leaf covering was gently removed before taking the core. Soil samples were taken outside the building at the major entrance, and along the dripline and mid-yard area of two sides of the building. Soil samples were collected from children's play areas in a subsample of 375 homes. Soil samples were analyzed by inductively-coupled plasma atomic emission spectroscopy, using the SW-846 digestion method and the ELLAP proficiency testing procedures.

[7] ASTM E 1728-95. (1995b). *Standard practice for the field collection of settled dust samples using wipe sampling methods for lead determination by atomic spectrometry techniques*. American society of Testing and Materials, Philadelphia, PA.

Conclusion

This most recent HUD survey shows that the number of housing units with lead-based paint has declined from 64 million in 1990 to 38 million ten years later. Despite this decline, one in four homes with resident children under 6 years old have significant lead-based paint hazards.

1. INTRODUCTION

The National Survey of Lead and Allergens in Housing (referred to here as the National Survey) was conducted under the sponsorship of the Department of Housing and Urban Development (HUD) and the National Institute of Environmental Health Sciences (NIEHS) to assess children's potential household exposure to lead and allergens, i.e., to estimate the levels of lead in dust, soil, and paint, the prevalence of hazardous levels of lead, and levels and patterns of various indoor allergens (allergy-inducing substances) in dust in homes. Combining the goals of HUD and NIEHS into a single survey saved significant public funds, reduced the survey response burden on the public, and substantially reduced the time required to obtain the data needed by both agencies for their ongoing primary and secondary prevention activities.

This report, Volume I, includes the findings for lead hazards, and describes lead levels in dust, soil, and paint in the nation's housing by age, type, geographical location, and exposed populations. In addition, the report estimates the number and percent of homes with dust and soil lead levels above selected thresholds, especially thresholds in HUD's Lead Safe Housing Rule (24 CFR Part 35 et al., *Requirements for Notification, Evaluation and Reduction of Lead-Based Paint Hazards in Federally Owned Residential Property and Housing Receiving Federal Assistance*, effective September 15, 2000) and in the *HUD Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing* (referred to as HUD 1995 *Guidelines*), as amended by the 1997 revision to its chapter 7 on lead-based paint inspection.

1.1 Background

Lead is a toxin that affects the central nervous system and is particularly damaging to the developing nervous system of young children and fetuses. High blood lead levels can result in convulsions, mental retardation, and even death. Research has shown that even low lead levels can have serious health consequences. These include reduced intelligence and short-term memory, slower reaction times, poorer hand-eye coordination, reduced height, hearing problems and numerous behavioral problems.[8]

Although there are many sources of lead in the environment, including drinking water, food, emissions from gasoline combustion, and industrial emissions, it is clear that lead-based paint (LBP) plays

[8] National Academy of Sciences (1993). *Measuring lead exposure in infants, children, and other sensitive populations.* National Academy Press, Washington, DC.

a major role in high blood lead levels among children today. Research indicates that dust and soil may be the most significant pathways for low-level lead exposure, and that LBP is the major important source of household dust lead.[9,10]

The fundamental purpose of the Residential Lead-Based Paint Hazard Reduction Act of 1992, which is Title X of the Housing and Community Development Act of 1992 (P.L. 102-550) is prevention, i.e., to find and mitigate LBP hazards in homes before children are poisoned. In Sections 1051 and 1052(10), Congress required HUD to conduct research on risk reduction strategies from household-based lead exposure, and to assess the effectiveness of lead hazard evaluation activities, respectively. The National Survey was undertaken to provide current information needed for regulatory and policy decisions and for assessment of the effectiveness of lead hazard reduction strategies, e.g., lead information disclosure during housing sale or lease transactions and certification of LBP professionals.

In 1989-1990, HUD sponsored a national survey of LBP in housing (referred to as the 1990 LBP Survey). The primary objective of that survey was to estimate the prevalence of LBP in housing - not to address the presence of lead-based hazards in the housing.[11] While some data on lead in exterior soil and house dust was collected during the paint survey, there have been advances in the understanding of the sources and pathways of lead transport and exposure, advances in the protocols for collecting samples of paint and dust for lead contamination, and improvements in the understanding of the susceptibility of children to the effects of lead exposure in the intervening years. For example, it is now understood that lead-contaminated house dust from LBP is most often the primary lead hazard for children.[12,13,14] Also, HUD now recommends, and HUD and EPA require in their regulations, the use of dust wipe sampling as opposed to the vacuum sampling employed in the 1990 LBP Survey. In addition, the 1990 survey data are dated because the housing stock has continued to evolve as older houses are

[9] Bornschein, R., Hammond, P.B., Dietrich, et al. (1985a). The Cincinnati prospective study of low-level lead exposure and its effects on child development: Protocol and status report. Environ. Res. 38:4-18.

[10] Bornschein, R., Succop, P., Dietrich, et al. (1985b). *The influence of social and environmental factors on dust lead, hand lead, and blood lead levels in young children*. Environ. Res. 38:108-118.

[11] In Title X of the Housing and Community Development Act of 1992 (P.L. 102-550), the term "lead-based paint hazard" means any condition that causes exposure to lead from lead-contaminated dust, lead-contaminated soil, lead-contaminated paint that is deteriorated or present in accessible surfaces, friction surfaces, or impact surfaces that would result in adverse human health effects as established by the appropriate Federal agency.

[12] Clark, S., Bornschein, R., Succop, P., et al. (1985). *Conditions and type of housing as an indicator of potential environmental lead exposure and pediatric blood lead levels.* Environ. Res. 38, pp. 46-53.

[13] Centers for Disease Control and Prevention (1991). *Preventing Lead Poisoning in Young Children*. Centers for Disease Control and Prevention, U.S. Department of Health and Human Services, Atlanta, GA.

[14] Lanphear, B.P., et al. (1995). *The Relation of Lead-Contaminated House Dust and Blood Lead Levels Among Urban Children, Final Report*. Report to the U.S. Department of Housing and Urban Development.

renovated, repaired and/or demolished. Thus, it may not serve as an appropriate estimate for evaluation of current LBP hazard reduction strategies. Finally, the 1990 LBP Survey excluded certain housing categories such as manufactured housing, and housing built after 1977 (i.e., after the Consumer Product Safety Commission's ban on lead-containing residential paint went into effect).

The National Survey has updated HUD's 1990 LBP Survey and will enable an assessment of progress in making the U.S. housing stock lead-safe. Further, it provides current baseline information needed for regulatory and policy decisions and for assessment of the effectiveness of lead hazard reduction strategies currently under development.

1.2 Survey Objectives

HUD's principal lead-related purpose for the National Survey was to develop a scientific description of the existing lead levels in dust, soil, and paint in the Nation's housing. In addition, the survey of lead hazards in homes collected data to:

i. Estimate the number and percent of homes with dust and soil lead levels above selected thresholds.

ii. Identify likely sources of lead in dust in housing, e.g., paint and soil.

iii. Permit future analyses of lead hazard control strategies and costs, e.g., quantities of deteriorated painted surfaces.

iv. Permit future analyses for regulation, policy, and guidance that minimize regulatory and program implementation burden.

In order to meet the survey objectives, a nationally-representative sample of 1,984 housing units (HUs) was drawn from 75 clusters called *primary sampling units* (PSUs).[15] A general three-stage sample design was utilized to accomplish these goals as efficiently as possible. A total of 831 eligible HUs were recruited into the survey. In each recruited HU, samples of dust and soil were collected and painted surfaces were tested. (See Volume II: *Design and Methodology* for details on design and data collection protocols.)

[15] A PSU is a metropolitan statistical area (MSA), county, or cluster of counties that have a minimum population of 15,000 and do not cross Census region boundaries.

1.2.1 Technical Note on the Survey Weights

Paint lead measurements, dust samples and general area soil samples were collected from all 831 homes in the sample. In contrast, data on the presence of children's play areas and play area soil samples were collected from a nationally representative statistical subsample of 375 homes in the sample. Consequently, two sets of survey sampling weights have been developed: one for the full sample of 831 surveyed homes; and one for the subsample of 375 homes with play area soil lead data. The construction of these weights is described in Volume II. Both sets of weights are unbiased; they will both produce unbiased national estimates to characterize the target population of all 95.7 million occupied housing units in the U.S. where children are permitted to live. However, the play area subsample, being smaller, will have wider confidence intervals than the full sample. Throughout this report, national estimates that involve play area soil lead data (including estimates of lead-based paint hazard) are based on the 375 home subsample and its survey sampling weights, while estimates that do not involve play areas are based on the full 831 home sample and its weights.

1.3 Report Organization

The report for the National Survey consists of two volumes: Volume I presents the major lead hazard findings. Volume II presents the survey design and methodology. The findings on bedroom allergens are presented in a separate Volume.

There are seven chapters in Volume I, including this introduction. Descriptions of each chapter are as follows:

- Chapter 2 describes the population surveyed and compares the survey population to Current Population Survey (CPS) and American Housing Survey (AHS) populations.
- Chapter 3 presents the estimates of the prevalence of significant LBP hazards in housing, based on the findings presented in Chapters 4, 5 and 6 for paint, dust, and soil, respectively. The association between lead in each of the matrices (paint, dust, soil) is presented, as well as the prevalence of lead-related occupations and hobbies among housing residents.
- Chapter 4 presents the estimates of the prevalence and amount of LBP and deteriorated LBP in housing, including paint lead loadings in housing.[16] Relevant estimates are compared with the findings of the 1990 LBP Survey.

[16] Throughout the volume, the concepts of lead loading and lead concentration are used. Loading applies to the amounts of lead in paint and dust, while concentration applies to the amount of lead in soil. For paint, lead loading is the number of milligrams of lead per

- Chapter 5 presents the estimates of the prevalence of lead-contaminated dust in housing, including the dust lead loadings and the association between interior dust lead and LBP condition. Relevant estimates are compared with the findings of the 1990 LBP Survey.

- Chapter 6 presents the estimates of the prevalence of residential soil lead, including soil lead concentrations and the association between soil lead and exterior LBP condition. Relevant estimates are compared with the findings of the 1990 LBP Survey.

- Chapter 7 examines the quality of the data and the resulting quality of projected national estimates. In order to do this, the chapter addresses nonresponse rates and classification bias due to measurement error. A summary of field data collection quality control activities is also provided.

square centimeter of painted surface (mg/cm^2). For dust, lead loading is the number of micrograms of lead per square foot of wiped surface ($\mu g/ft^2$). Soil is reported as the number of micrograms of lead per gram of soil ($\mu g/g$), equivalent to parts per million (ppm).

2. SURVEYED HOUSING POPULATION

The National Survey population included the national housing stock of permanently-occupied, noninstitutional housing units (HUs), including multi-family buildings and manufactured HUs, i.e., mobile homes and trailers. Homes built in all age categories were included. Homes built before 1978 were included to update and expand upon the findings of the 1990 LBP Survey. Homes built in 1978 or after were included to verify the assumption that newer homes have minimal lead hazards, based on the 1978 ban of lead-based paint (LBP) for residential use. Vacant housing, group quarters, hotels and motels, military bases, and short-term housing were excluded for operational reasons and are consistent with exclusions under the Lead Safe Housing Rule. Housing where children were not permitted to live, e.g., elderly care facilities, were excluded because the primary interest was in children's exposure to lead and allergens. However, a home was not excluded simply because a child was not currently residing in the home at the time of the survey. With these exclusions, the eligible national housing stock consisted of approximately 96 million housing units.

A nationally-representative sample of 1,984 HUs was drawn from 75 clusters called *primary sampling units* (PSUs), whose derivation is described in Volume II. A total of 831 eligible HUs were recruited and completed the survey. Table 2.1 presents the national estimates for selected characteristics of the survey population, including year of construction, geographic region, degree of urbanization, presence of children under age 6 and age 18, tenure, income, poverty, government support, race, and ethnicity.[17] All estimates presented are weighted national estimates as discussed in Volume II. Results reported in Chapters 3 and 6 include data from play area soil samples and are therefore restricted to the 375 eligible HUs in 40 PSUs from which play area samples were collected. Chapter 7 of this volume presents an extensive discussion of the potential effect of nonresponse bias.

One important measure of the representativeness of the National Survey is to examine how the distributions of the housing characteristics, socioeconomic and demographic factors compare to national distributions. National distributions were obtained from the 1997 American Housing Survey (AHS) and the 1998 and 1999 Current Population Surveys (CPS). The weighted percent distribution of the National Survey sample by race, ethnicity, income, presence of a child under 18,[18] Census region, year

[17] Cross comparisons of two variables, e.g., Region by Construction Year and Poverty by Urbanization, result in cells containing 30 or fewer HUs. Caution is recommended in the interpretation of these results.

[18] While we were most interested in children under the age of six years, available comparative data from the AHS is based on children under age 18 in the household. For the same reason, post-stratification for this survey was based on children under age 18.

of construction, single family vs. multi-family, metropolitan status, and tenure (owned vs. rented) were compared with that of the available AHS and CPS data.[19]

The 95 percent confidence intervals for the National Survey sample estimate were found to contain the AHS or CPS estimate for most of the available statistics. Slight differences in estimates were observed as follows:

- The 1997 AHS estimate of 35 percent of all homes being in the South is slightly lower than the survey estimate of 36 percent to 39 percent of all homes being in the South.
- The 1997 AHS estimate of 37 percent of all homes having children under age 18 is slightly lower than the survey estimate of 38 percent to 39 percent of all homes.
- The 1998 CPS estimate of 26 percent of all household incomes falling in the $0-19,999 range is slightly higher than the survey estimate of 17 percent to 24 percent of all households in this income range.
- The 1998 CPS estimate of 85 percent of all households not in poverty is slightly higher than the survey estimate of 77 percent to 83 percent of all households not in poverty.

A few items should be noted which affect the comparability of the estimates and may explain the above observed differences. The first is that the target population for the National Survey excludes housing that excludes children, whereas the AHS and CPS estimates include such housing. Second, for the income and poverty comparisons, the CPS uses the family size and income to determine poverty status, whereas the National Survey has used household size and income.[20] National Survey estimates of any particular income class are also deflated due to the 9 percent of respondents whose income level is unknown. Similarly, there are 6 percent of respondents whose poverty status is unknown. Third, race and ethnicity are based on the youngest household member for the National Survey, while the AHS bases these data on the first householder identified over the age of 18. Finally, the most recent AHS available is for 1995 and 1997, thus the AHS data is slightly out of date as compared to the National Survey.

[19] If AHS or CPS data are not listed in Table 2.1, e.g., for One or More Children Under Age 6, they were not available in these sources.

[20] Family size includes all related people living in a housing unit. Household size includes all people living the housing unit, whether or not they are related to each other. Thus household size tends to be larger than family size.

Table 2.1 Characteristics of the National Survey Population, with Comparisons to the American Housing Survey (AHS) and the Current Population Survey (CPS)

HU Characteristic	National Survey Estimates				HUs in sample	AHS (1997)	CPS (1998-99)[3]
	Estimate (000)	Estimate (%)[1]	Lower 95% CI[2] (%)	Upper 95% CI (%)			
Total Housing Units[4]	95,688	100%			831		
Construction year:							
1978-1998	29,774	31%	30%	32%	220	30%	
1960-1977	27,874	29%	28%	30%	267	30%	
1940-1959	20,564	21%	20%	23%	186	20%	
Before 1940	17,476	18%	17%	20%	158	20%	
Region:							
Northeast	19,290	20%	19%	22%	155	20%	
Midwest	22,083	23%	22%	24%	196	24%	
South	35,474	37%	36%	39%	277	35%	
West	18,841	20%	18%	21%	203	21%	
Urbanization:							**1999**
MSA equal to or above 1 million population	26,814	28%	24%	32%	276		30%
MSA below 1 million population	45,753	48%	43%	53%	417		47%
Non-MSA	23,121	24%	19%	30%	138		23%
One or more children under age 6	16,402	17%	15%	19%	184		
Refusal/Don't Know[5]	352				5		
One or more children under age 18	36,994	39%	38%	39%	398	37%	
Refusal/Don't Know	290				3		
Housing Unit Type:							
Single family	82,651	86%	84%	89%	705	88%	
Multi-family	13,037	14%	11%	16%	126	12%	
Tenure:							**1999**
Owner-occupied	66,232	69%	65%	73%	539		67%
Renter-occupied	29,074	30%	27%	34%	289		33%
Refusal/Don't Know	381				3		
Household Income ($30,000):							**1998**
Less than $30,000/year	33,830	35%	30%	41%	309		40%
Equal to or more than $30,000/year	56,111	59%	54%	63%	482		60%
Refusal/Don't Know	5,747				40		
Household Income ($20,000):							**1998**
$0-19,999/year	19,359	20%	17%	24%	189		26%
$20-39,999/year	25,855	27%	23%	31%	228		27%
$40-59,999/year	19,316	20%	16%	25%	152		19%
Equal to or more than $60,000/year	22,890	24%	20%	28%	203		28%
Refusal/Don't Know	8,268				59		

Table 2.1 Characteristics of the Survey Population, with Comparisons to the American Housing Survey (AHS) and the Current Population Survey (CPS) (continued)

HU Characteristic	National Survey Estimates				HUs in sample	AHS (1997)	CPS (1998-99)[3]
	Estimate (000)	Estimate (%)	Lower 95% CI (%)	Upper95% CI (%)			
Government Support:							
Government support	4,809	5%	3%	7%	54		
No Government support	86,070	90%	88%	92%	733		
Refusal/Don't Know	4,809	5%			44		
Poverty:							**1998**
In poverty	13,221	14%	11%	16%	137		15%
Not in poverty	76,336	80%	77%	82%	651		85%
Refusal/Don't Know	6,130	6%			43		
Race:							
White	77,005	80%	78%	83%	622	83%	
African American	10,365	11%	9%	13%	116	12%	
Other[6]	6,571	7%	5%	8%	77	6%	
Refusal/Don't Know	1,746	2%			16		
Ethnicity:							
Hispanic/Latino	7,434	8%	6%	10%	86	9%	
Not Hispanic/Latino	87,008	91%	88%	93%	736	91%	
Refusal/Don't Know	1,246	1%			9		
Region by Construction year:							
Northeast	19,290	20%	19%	22%	155		
1978-1998	4,358	5%	3%	6%	30		
1960-1977	3,754	4%	3%	5%	30		
1940-1959	4,261	5%	4%	20%	36		
Before 1940	6,917	7%	6%	8%	59		
Midwest	22,083	23%	22%	24%	196		
1978-1998	4,801	5%	4%	6%	41		
1960-1977	6,283	7%	6%	7%	55		
1940-1959	5,899	6%	5%	7%	47		
Before 1940	5,101	5%	5%	6%	53		
South	35,474	37%	36%	39%	277		
1978-1998	14,447	15%	14%	17%	95		
1960-1977	11,261	12%	11%	12%	96		
1940-1959	6,320	7%	6%	7%	57		
Before 1940	3,445	4%	3%	4%	29		
West	18,841	20%	17%	21%	203		
1978-1998	6,169	6%	5%	8%	54		
1960-1977	6,536	7%	6%	7%	85		
1940-1959	4,124	4%	3%	6%	47		
Before 1940	2,013	2%	1%	3%	17		

Table 2.1 Characteristics of the Survey Population, with Comparisons to the American Housing Survey (AHS) and the Current Population Survey (CPS) (continued)

HU Characteristic	National Survey Estimates				HUs in sample	AHS (1997)	CPS (1998-99)[3]
	Estimate (000)	Estimate (%)	Lower 95% CI (%)	Upper95% CI (%)			
Poverty by Urbanization:							
MSA equal to or above 1 million population	26,814	28%	24%	32%	276		
In poverty	2,962	3%	2%	4%	35		
Not in poverty	22,005	23%	19%	27%	226		
Refusal/Don't Know	1,847	2%			15		
MSA below 1 million population	45,753	48%	43%	53%	417		
In poverty	6,996	7%	5%	9%	75		
Not in poverty	35,786	37%	34%	41%	323		
Refusal/Don't Know	2,971	3%			19		
Non-MSA	23,121	24%	19%	30%	138		
In poverty	3,264	3%	2%	5%	27		
Not in poverty	18,544	19%	14%	25%	102		
Refusal/Don't Know	1,313	1%			9		

[1] All percentages are calculated with total housing units (95,688) as the denominator. Percentages may not total 100% due to rounding.

[2] CI = 95% confidence interval for the estimated number or percent.

[3] Current Population Survey (CPS) data was taken from either 1998 or 1999 CPS, as indicated by the boldface year at the top of each section of the column.

[4] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[5] Refusals and "don't know" responses by survey respondents.

[6] "Other" race includes Asian, American Indian or Alaskan Native, Native Hawaiian or other Pacific Islander, and more than one race.

3. LEAD-BASED PAINT (LBP) HAZARDS IN HOUSING

Chapter 3 presents the estimates of the prevalence of lead-based paint (LBP) hazards in housing, based on the findings presented in Chapters 4, 5, and 6. The associations between lead in each of the matrices (paint, dust, soil) are presented. In addition, the prevalence of lead-related behaviors, occupations, and hobbies among housing residents is presented. No comparison is made with the dust lead findings of the 1990 LBP Survey because the concept of hazard from the earlier survey is not comparable to the definitions in use today. The effect of measurement error on the estimates is discussed in Section 7.3.

As will be seen below, the definition of lead-based paint hazard involves lead-contaminated soil in children's play areas. Therefore, as described in Chapter 1 and Volume II, estimates of the prevalence of significant LBP hazards are based on the play area subsample and its survey sample weights.

3.1 Definitions of Lead-Based Paint (LBP) Hazards

The number of housing units (HUs) classified as having a LBP hazard depends on the definition employed in such classification. A LBP hazard is defined as "any condition that causes exposure to lead from lead-contaminated dust; bare, lead contaminated soil; LBP that is deteriorated; or LBP present on accessible surfaces, friction surfaces, or impact surfaces." Three operational definitions have been utilized in the analysis of the National Survey data. The first definition defines *significant lead-based paint (LBP) hazards* in accordance with the HUD Lead Safe Housing Rule (24 CFR 35). This definition will be the focus of the results presented in this chapter and later in the body of this report:

Definition I: Significant LBP Hazard, HUD Lead Safe Housing Rule

If any of the following situations exist in a home, then a significant LBP hazard exists in the home under this definition:

- Deteriorated LBP – LBP with deterioration larger than the *de minimis* levels per Section 35.1350(d) of the Lead Safe Housing rule, viz., deterioration of more than 20 square feet (exterior) or 2 square feet (interior) of LBP on large surface area components (walls, doors) or damage to more than 10% of the total surface area of

interior small surface area components types (window sills, baseboards, trim).[20] LBP is defined as any paint or other surface coating (e.g., varnish, lacquer, or wallpaper over paint) that contains lead equal to or greater than 1.0 mg/cm^2; or

- Lead-contaminated dust – Dust on floors with greater than or equal to 40 µg/ft^2 lead, dust on window sills with greater than or equal to 250 µg/ft^2 lead[21]; or

- Bare, lead-contaminated soil – More than 9 square feet of bare soil with a lead concentration greater than or equal to 2,000 ppm lead, or 400 ppm for bare soil in an area frequented by a child under the age of 6 years.

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Definition Ib: Significant LBP Hazard, EPA Identification of Dangerous Levels of Lead Rule

The EPA Identification of Dangerous Levels of Lead Rule, (40 CFR 745), issued under Section 403 of the Toxic Substances Control Act, contains a different definition of soil lead hazard than that contained in Definition I, viz., the EPA Section 403 rule uses 1,200 ppm as the threshold for soil lead concentrations outside of children's play areas. This leads to a variation on definition I for a significant LBP hazard -- if any of the following situations exist in a home, then a LBP hazard exists under this definition:

- Deteriorated LBP and Lead-contaminated dust – same as Definition I

- Bare, lead-contaminated soil – More than 9 square feet of bare soil with a lead concentration greater than or equal to 1,200 ppm lead, or 400 ppm for bare soil in an area frequented by a child under the age of 6 years.

The second definition of a LBP hazard is also based on the HUD Lead Safe Housing Rule (24 CFR 35). This definition differs from the first one by including deteriorated LBP below the *de minimis* thresholds that define a significant LBP hazard and excluding play area soil. The third definition was in place at the start of the study; it is presented in the 1995 HUD *Guidelines*. LBP hazard findings obtained under the second and third definitions may be found in Appendix A. The second and third definitions follow.

Definition II: Any LBP Hazard, HUD Lead Safe Housing Rule

[20] Intact LBP present on accessible surfaces, friction surfaces, or impact surfaces were not included in the definition of LBP hazard for the estimates presented in this report because this information was not specifically collected for each component.

[21] Window trough dust is not considered in the definition of a LBP hazard under the HUD Lead Safe Housing Rule.

The second definition of a LBP hazard is based on the HUD Lead Safe Housing Rule (24 CFR 35). It includes both *de minimis* and significant LBP hazards. If any of the following situations exist in a home, then a LBP hazard exists under this definition:

- Deteriorated LBP – LBP with any deterioration, where, as before, LBP is defined as any paint or other surface coating (e.g., varnish, lacquer, or wallpaper over paint) that contains lead equal to or greater than 1.0 mg/cm^2; or
- Lead-contaminated dust – Dust on floors with greater than or equal to 40 µg/ft^2 lead, dust on window sills with greater than or equal to 250 µg/ft^2 lead[22]; or
- Bare, lead-contaminated soil – More than 9 square feet of bare soil with a lead concentration greater than or equal to 2,000 ppm lead, or 400 ppm for bare soil in an area frequented by a child under the age of 6 years.

Definition III: LBP Hazard, 1995 HUD *Guidelines*

The third definition of a LBP hazard is based on the 1995 HUD *Guidelines*. If any of the following situations exist in a home, then a LBP hazard exists under this definition:

- Deteriorated LBP – LBP in poor condition. LBP is defined as any paint or other surface coating (e.g., varnish, lacquer, or wallpaper over paint) that contains lead equal to or greater than 1.0 mg/cm^2. The HUD *Guidelines* define poor condition as damage to more than 10 square feet (exterior) or 2 square feet (interior) of LBP on large surface area components (walls, doors) or damage to more than 10% of the surface area of small surface area components (window sills, baseboards, trim)[23]; or
- Lead-contaminated dust – Dust on floors with greater than 100 µg/ft^2 lead, dust on window sills with greater than 500 µg/ft^2 lead, or dust on window troughs with greater than 800 µg/ft^2 lead; or
- Bare, lead-contaminated soil – Any bare soil with a lead concentration greater than 2,000 ppm lead.

[22] Window trough dust is not considered in the definition of a LBP hazard under the HUD Lead Safe Housing Rule.
[23] Intact LBP present on accessible surfaces, friction surfaces, or impact surfaces were not included in the definition of LBP hazard for the estimates presented in this report because this information was not specifically collected for each component.

3.2 Prevalence of Significant Lead-Based Paint Hazards in Housing

An estimated 25 million (±5 million[24]) or 26 percent (±6%) of housing units in the United States have significant LBP hazards. Table 3.1 presents the number and percentage of housing units with significant LBP hazards by selected characteristics.

Homes in Northeastern and Midwestern states are more likely to have significant LBP hazards than homes in Southern or Western states. An estimated 43 percent (±12%) of homes in the Northeast have significant LBP hazards, while the estimates are 16 percent (±9%) and 19 (±14%) percent for homes in the South and West, respectively. Older homes are more likely to have significant LBP hazards than newer homes. An estimated 10 percent (±9%) of homes built between 1960 and 1977 have significant LBP hazards, but the percentage increases to 51 percent (±12%) for homes built between 1940 and 1959, and to 67 percent (±17%) for homes built before 1940. Similar results were found for homes with children under age 6 categorized by age of construction.

[24] All confidence intervals are at the 95% level for the estimated number or percent.

Table 3.1 Prevalence of Housing Units with Significant Lead-Based Paint (LBP) Hazards, by Selected Characteristics

Characteristic	All HUs (000)[2]	No. of HUs with Significant LBP Hazards (000)			Percent of HUs with Significant LBP Hazards (%)[3]			HUs in Sample
		HUD Lead Safe Housing Rule: Significant LBP Hazards[1]						
		Estimate	Lower 95% CI[4]	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Total Occupied Housing Units	95,688	25,153	19,922	30,384	26%	21%	32%	375
Region:								
Northeast	19,290	8,260	5,929	10,592	43%	31%	55%	95
Midwest	22,083	7,606	5,711	9,501	34%	26%	43%	102
South	35,474	5,718	2,527	8,910	16%	7%	25%	111
West	18,841	3,569	1,030	6,108	19%	5%	32%	67
Construction year:								
1978-1998	29,774	61	0	203	0%	0%	1%	88
1960-1977	27,874	2,841	342	5,341	10%	1%	19%	111
1940-1959	20,564	10,511	8,045	12,978	51%	39%	63%	97
Before 1940	17,476	11,747	8,802	14,692	67%	50%	84%	79
One or More Children Under Age 6:								
All HU ages	16,402	4,430	2,886	5,974	27%	18%	36%	83
HUs built 1978-1998	5,847	0	0	0	0%	0%	0%	25
HUs built 1960-1977	5,098	390	0	1,006	8%	0%	20%	20
HUs built 1940-1959	3,055	1,896	1,097	2,695	62%	36%	88%	22
HUs built before 1940	2,401	1,935	1,318	2,401	81%	55%	100%	16
Housing Unit Type:								
Single family	82,651	22,211	16,894	27,528	27%	20%	33%	319
Multi-family	13,037	2,819	114	5,523	22%	1%	42%	56
Occupant Status:								
Owner-occupied	66,232	14,838	11,657	18,018	22%	18%	27%	254
Renter-occupied	29,074	10,757	7,223	14,290	37%	25%	49%	119
Refusal/Don't Know[5]	381							0%
Household Income:								
Less than $30,000/year	33,830	13,052	7,924	18,181	39%	23%	54%	145
Equal to or more than $30,000/year	56,111	9,941	6,719	13,164	18%	12%	23%	211
Refusal/Don't Know	5,747							19
One or More children Under Age 6:								
All Income Categories	16,402	4,430	2,886	5,974	27%	18%	36%	83
Less than $30,000/year	4,791	1,369	64	2,673	29%	1%	56%	28
Equal to or more than $30,000/year	11,236	3,094	1,542	4,645	28%	14%	41%	52
Refusal/Don't Know	375							3
Government Support:								
Government support	4,809	925		1,903	19%	0%	40%	25
No government support	86,070	23,406	18,797	28,016	27%	22%	33%	327
Refusal/Don't Know	4,809							23

Table 3.1 Prevalence of Housing Units with Significant Lead-Based Paint (LBP) Hazards, by Selected Characteristics (continued)

Characteristic	All HUs (000)[2]	HUD Lead Safe Housing Rule: Significant LBP Hazards[1] No. of HUs with Significant LBP Hazards (000)			Percent of HUs with Significant LBP Hazards (%)[3]			HUs in Sample
		Estimate	Lower 95% CI[4]	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Poverty:								
In Poverty	13,221	5,388	3,529	7,248	41%	27%	55%	54
Not in Poverty	76,336	17,852	13,990	21,714	23%	18%	28%	300
Refusal/Don't Know	6,130							21
Race:								
White	77,005	18,768	15,204	22,332	24%	20%	29%	285
African American	10,365	2,929	918	4,941	28%	9%	48%	45
Other[6]	6,571	2,303	474	4,133	35%	7%	63%	35
Refusal/Don't Know	1,746	861		1,746	49%	0%	100%	10
Ethnicity:								
Hispanic/Latino	7,434	4,741	3,455	6,027	64%	46%	81%	31
Not Hispanic/Latino	87,008	20,258	16,062	24,455	23%	18%	28%	337
Refusal/Don't Know	1,246							7

[1] Significant LBP hazard as defined in text and HUD Lead Safe Housing Rule.
[2] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.
[3] All percentages are calculated with the "All HUs" column in each row used as the denominator.
[4] CI = 95% confidence interval for the estimated number or percent.
[5] Refusals and "don't know" responses by survey respondents.
[6] "Other" race includes Asian, American Indian or Alaskan Native, Native Hawaiian or other Pacific Islander, and more than one race.

More homes with lower income occupants have significant LBP hazards than homes where occupants have higher incomes. An estimated 39 percent (±16%) of households with less than $30,000/year income have significant LBP hazards, compared with 18 percent (±6%) of households in the $30,000/year or above income level.

Government-supplied housing may have fewer lead-based paint hazards than housing without Government support. An estimated 19 percent of Government-supported housing had significant lead-based paint hazards, compared to 27 percent of housing without Government support.

Table 3.2 presents the number of homes with significant LBP hazards by location in the building–either interior or exterior, or both.

Table 3.2 Prevalence of Significant Lead-Based Paint (LBP) Hazards by Location in the Building

HUD Lead Safe Housing Rule: Significant LBP Hazards							
LBP Hazard Location	**Number of HUs[1] (000)**			**Percent of HUs[2]**			**HUs in Sample**
	Estimate	**Lower 95% CI[3]**	**Upper 95% CI**	**Percent**	**Lower 95% CI**	**Upper 95% CI**	
Interior only	10,497	6,361	14,633	11%	7%	15%	46
Both Interior and Exterior	7,965	4,905	11,026	8%	5%	12%	39
Exterior only	6,690	3,649	9,731	7%	4%	10%	29
Anywhere	25,153	19,922	30,384	26%	21%	32%	114
No Significant LBP Hazard	70,535	65,304	75,766	74%	68%	79%	261
Total HUs	95,688			100%			375

[1] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[2] All percentages are calculated with total housing units (95,688) as the denominator. Percentages may not total 100% due to rounding.

[3] CI = 95% confidence interval for the estimated number or percent.

Table 3.3 presents data for the presence of significant LBP hazards in homes by type of hazard, for all homes in the National Survey's target population and for homes with one or more children under the age of 6 years. The percentages for each "All HU's" row of Table 3.3 show the percent of all HUs with the component of significant LBP hazard, while the percentages in each "HU's w/Child Under 6" row of Table 3.3 show the percent of all HUs with a child under age 6 with that component of significant LBP hazard.

Figures 3.1 and 3.2 show the proportion of each significant LBP hazard attributable to each type of hazard, for all homes and for homes in the National Survey's target population with one or more children under the age of 6 years.

Table 3.3 Prevalence of Significant Lead-Based Paint (LBP) Hazards in Housing Units with a Child Under 6 Years of Age by Type of Hazard

HUD Lead Safe Housing Rule: Significant LBP Hazards						
Type of Hazard	**Number of HUs[1] (000)**			**Percent of HUs[2] (%)**		
	Estimate	**Lower 95% CI[3]**	**Upper 95% CI**	**Estimate**	**Lower 95% CI**	**Upper 95% CI**
Significantly Deteriorated Lead Based Paint						
All HUs	14,124	10,683	17,566	15%	11%	18%
HUs w/ Child Under 6	2,950	1,328	4,573	18%	8%	28%
Interior Lead Dust						
All HUs	16,431	11,655	21,206	17%	7%	26%
HUs w/ Child Under 6	2,742	1,168	4,316	15%	5%	25%
Lead Contaminated Soil						
All HUs	5,572	2,487	8,657	6%	3%	9%
HUs w/ Child Under 6	1,189	0	2,555	7%	0%	16%
Any LBP Hazard						
All HUs	25,153	19,922	30,384	26%	21%	32%
HUs w/ Child Under 6	4,430	2,886	5,974	27%	18%	36%

[1] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[2] Percentages are calculated with total housing units (95,688) or with housing units with a child under age 6 (16,402) as the denominator, or as applicable.

[3] CI = 95% confidence interval for the estimated number or percent.

Figure 3.1 Significant Lead-Based Paint (LBP) Hazards in Housing Units (HUs) by Hazard Characteristic (HUD Lead Safe Housing Rule)

Figure 3.2 Significant Lead-Based Paint (LBP) Hazards in Housing Units (HUs) with Children Under Age 6 by Hazard Characteristic (HUD Lead Safe Housing Rule)

3.3 Significant LBP Hazards with Alternate Threshold for Soil Lead Hazards

The EPA Identification of Dangerous Levels of Lead Rule, (40 CFR 745), issued under Section 403 of the Toxic Substances Control Act, contains a different definition of soil lead hazard than that contained in the HUD Lead Safe Housing Rule. The EPA Section 403 rule uses 1,200 ppm as the threshold for soil lead concentrations outside of children's play areas, rather than 2,000 ppm. To explore the implications of this difference, this section reproduces Tables 3.1, 3.2, and 3.3, as Tables 3.4, 3.5, and 3.6, respectively, for the alternate soil lead threshold. A comparison of Tables 3.4, 3.5, and 3.6 with Tables 3.1, 3.2, and 3.3 shows that the proposed change would result in a very slight increase in the number of housing units with LBP hazards, in the range of zero to one percent for all estimates[25].

3.4 Prevalence of Lead-Related Occupations or Hobbies

Table 3.7 presents the number and percent of households in which at least one occupant engages in a lead-related occupation or hobby. Data for home cleanliness and clutter categories are also presented. As described below, all of these estimates are likely to overstate the number of households that may have contribution to lead in dust from these behaviors.

An estimated 24 percent (±3%) of households report that at least one occupant engages in a listed lead-related occupation, e.g., construction or renovation work, lead industry work, automotive repair or radiator work, or firing range work. This may be elevated above the actual estimate of people who may bring lead home due to the fact that many people in the construction business only work with new construction or in projects which that do not involve disturbing LBP, dust-lead hazards or soil-lead hazards. Similarly, a person working in a lead-related industry may have an administrative position and have no lead exposure at all.

An estimated 41 percent (±5%) report that at least one occupant engages in a potentially lead-related hobby at home, e.g., making bullets or sinkers, furniture or home renovation, stained glass, pottery, or making jewelry.[26] This may be a high estimate of the number of homes where lead dust is actually generated since some of these people may generally or always use lead-free materials in their hobbies.

[25] In comparing Tables 3.2 and 3.5, it is to be noted that all rows depend on the presence of both interior and exterior LBP hazards, and may therefore have different estimates in the two tables.

[26] Painting and renovation work on homes built after 1978 were excluded from these estimates.

Table 3.4 Prevalence of Housing Units with Significant Lead-Based Paint (LBP) Hazards, by Selected Characteristics. Alternative Soil Lead Threshold at 1,200 ppm per EPA Section 403 Rule

Characteristic	All HUs (000)[2]	EPA Section 403 Rule: Significant LBP Hazards[1] Number of HUs with Signif. LBP Hazards (000)			Percent of HUs with Significant LBP Hazards (%)[3]			HUs in Sample
		Estimate	Lower 95% CI[4]	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Total Occupied Housing Units	95,688	25,334	20,204	30,464	26%	21%	32%	375
Region:								
Northeast	19,290	8,350	6,173	10,527	43%	32%	55%	95
Midwest	22,083	7,697	5,894	9,501	35%	27%	43%	102
South	35,474	5,718	2,527	8,910	16%	7%	25%	111
West	18,841	3,569	1,030	6,108	19%	5%	32%	67
Construction year:								
1978-1998	29,774	61	0	203	0%	0%	1%	88
1960-1977	27,874	2,841	342	5,341	10%	1%	19%	111
1940-1959	20,564	10,511	8,045	12,978	51%	39%	63%	97
Before 1940	17,476	11,928	9,081	14,776	68%	52%	85%	79
One or More Children Under Age 6:								
All HU ages	16,402	4,507	2,950	6,064	27%	18%	37%	83
HUs built 1978-1998	5,847	0	0	0	0%	0%	0%	25
HUs built 1960-1977	5,098	390	0	1,006	8%	0%	20%	20
HUs built 1940-1959	3,055	1,896	1,097	2,695	62%	36%	88%	22
HUs built before 1940	2,401	2,014	1,406	2,401	84%	59%	100%	16
Housing Unit Type:								
Single family	82,651	22,388	17,157	27,618	27%	21%	33%	319
Multi-family	13,037	2,819	114	5,523	22%	1%	42%	56
Occupant Status:								
Owner-occupied	66,232	14,838	11,657	18,018	22%	18%	27%	254
Renter-occupied	29,074	10,962	7,498	14,426	38%	26%	50%	119
Refusal/Don't Know[5]	381							0%
Household Income:								
Less than $30,000/year	33,830	13,138	8,028	18,247	39%	24%	54%	145
Equal to or more than $30,000/year	56,111	10,033	6,892	13,175	18%	12%	23%	211
Refusal/Don't Know	5,747							19
One or More children Under Age 6:								
All Income Categories	16,402	4,507	2,950	6,064	27%	18%	37%	83
Less than $30,000/year	4,791	1,445	156	2,734	30%	3%	57%	28
Equal to or more than $30,000/year	11,236	3,094	1,542	4,645	28%	14%	41%	52
Refusal/Don't Know	375							3
Government Support:								
Government support	4,809	1,029	26	2,032	21%	1%	42%	25
No government support	86,070	23,497	18,940	28,053	27%	22%	33%	327
Refusal/Don't Know	4,809							23

Table 3.4 Prevalence of Housing Units with Significant Lead-Based Paint (LBP) Hazards, by Selected Characteristics. Alternative Soil Lead Threshold at 1,200 ppm per EPA 403 Rule (continued)

EPA Section 403 Rule: Significant LBP Hazards [1]								
Characteristic	**All HUs (000)[2]**	**No. of HUs with Significant LBP Hazards (000)**			**Percent of HUs with Significant LBP Hazards (%)[3]**			**HUs in Sample**
		Estimate	**Lower 95% CI[4]**	**Upper 95% CI**	**Estimate**	**Lower 95% CI**	**Upper 95% CI**	
Poverty:								
In Poverty	13,221	5,486	3,588	7,383	41%	27%	56%	54
Not in Poverty	76,336	17,940	14,173	21,707	24%	19%	28%	300
Refusal/Don't Know	6,130							21
Race:								
White	77,005	18,949	15,522	22,377	25%	20%	29%	285
African American	10,365	2,929	918	4,941	28%	9%	48%	45
Other[6]	6,571	2,303	474	4,133	35%	7%	63%	35
Refusal/Don't Know	1,746	861	0	1,746	49%	0%	100%	10
Ethnicity:								
Hispanic/Latino	7,434	4,741	3,455	6,027	64%	46%	81%	31
Not Hispanic/Latino	87,008	20,438	16,336	24,539	23%	19%	28%	337
Refusal/Don't Know	1,246							7

[1] Significant LBP hazard as defined in text and HUD Lead Safe Housing Rule.

[2] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[3] All percentages are calculated with the "All HUs" column in each row used as the denominator.

[4] CI = 95% confidence interval for the estimated number or percent.

[5] Refusals and "don't know" responses by survey respondents.

[6] "Other" race includes Asian, American Indian or Alaskan Native, Native Hawaiian or other Pacific Islander, and more than one race.

Table 3.5 Prevalence of Significant Lead-Based Paint (LBP) Hazards by Location in the Building. Alternative Soil Lead Threshold at 1,200 ppm per EPA Section 403 Rule

EPA Section 403 Rule: Significant LBP Hazards							
LBP Hazard Location	**Number of HUs [1] (000)**			**Percent of HUs [2]**			**HUs in Sample**
	Estimate	**Lower 95% CI[3]**	**Upper 95% CI**	**Percent**	**Lower 95% CI**	**Upper 95% CI**	
Interior only	10,052	5,797	14,307	11%	6%	15%	46
Both Interior and Exterior	8,411	5,106	11,715	9%	5%	12%	39
Exterior only	6,871	3,846	9,897	7%	4%	10%	29
Anywhere	25,334	20,204	30,464	26%	21%	32%	114
No LBP Hazard	70,354	65,223	75,484	74%	68%	79%	261
Total HUs	95,688			100%			375

[1] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[2] All percentages are calculated with total housing units (95,688) as the denominator. Percentages may not total 100% due to rounding.

[3] CI = 95% confidence interval for the estimated number or percent.

Table 3.6 Prevalence of Significant Lead-Based Paint (LBP) Hazards in Housing Units with a Child under 6 Years of Age by Type of Hazard. Alternative Soil Lead Threshold at 1,200 ppm per EPA Section 403 Rule

HUD Lead Safe Housing Rule: Significant LBP Hazards						
Type of Hazard	**Number of HUs[1] (000)**			**Percent of HUs[2] (%)**		
	Estimate	**Lower 95% CI[3]**	**Upper 95% CI**	**Estimate**	**Lower 95% CI**	**Upper 95% CI**
Deteriorated Lead Based Paint						
All HUs	14,124	10,683	17,566	15%	11%	18%
HUs w/ Child Under 6	2,950	1,328	4,573	18%	8%	28%
Interior Lead Dust						
All HUs	16,431	11,655	21,206	17%	7%	26%
HUs w/ Child Under 6	2,742	1,168	4,316	15%	5%	25%
Lead Contaminated Soil						
All HUs	6,460	3,137	9,784	7%	3%	10%
HUs w/ Child Under 6	1,266	0	2,597	8%	0%	16%
Any LBP Hazard						
All HUs	25,334	20,204	30,464	26%	21%	32%
HUs w/ Child Under 6						

[1] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[2] Percentages are calculated with total housing units (95,688) or with housing units with a child under age 6 (16,402) as the denominator, or as applicable.

[3] CI = 95% confidence interval for the estimated number or percent.

Home cleanliness has been associated with lead dust levels.[27] About half of the homes were found to be clean (59%) and organized (43%), using the criteria in this survey.

[27] NSLAH (1998). *Evaluation of the HUD Lead-Based Paint Hazard Control Grant Program, Fifth Interim Report*, March 1998, Prepared for the U.S. Department of Housing and Urban Development by the National Center for Lead-Safe Housing.

Table 3.7 Prevalence of Housing Units with Selected Lead-Related Characteristics

Lead Related Behavior	Number of HUs (000)[1]			Percent of HUs (%)[2]			HUs in Sample
	Estimate[3]	Lower 95% CI[4]	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Lead Related Occupation	22,673	19,732	25,615	24%	21%	27%	203
Lead Related Hobby	39,281	35,020	43,543	41%	36%	46%	347
Cleanliness							
House Appears Clean	56,058	51,887	60,228	59%	54%	63%	462
Some Evidence of Cleaning	25,347	21,417	29,277	26%	22%	31%	237
No Evidence of Cleaning	9,646	7,577	11,714	10%	8%	12%	86
Clutter							
Clutter Organized	41,158	37,650	44,666	43%	40%	46%	347
Average Amount of Clutter	38,601	35,663	41,539	40%	37%	43%	336
No Organization	11,045	8,859	13,231	12%	9%	14%	100
Total HUs	95,688						831

[1] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[2] All percentages are calculated with total housing units (95,688) as the denominator. Percentages may not total 100% due to rounding.

[3] Estimates are based on the full weighted sample.

[4] CI = 95% confidence interval for the estimated number or percent.

4. LEAD-BASED PAINT (LBP) IN HOUSING

Chapter 4 presents estimates of the prevalence, location, and amount of lead-based paint (LBP) and deteriorated LBP in housing, including paint lead loadings in housing. Relevant estimates are compared with the findings of the 1990 LBP Survey. All estimates in this chapter are based on the full, weighted sample of 831 housing units.

Under both the Lead Safe Housing Rule and the *Guidelines*, LBP is defined as any paint or other surface coating (e.g., varnish, lacquer, or wall-paper over paint) that contains lead equal to or greater than 1.0 mg/cm^2. The estimates for deteriorated LBP and significantly deteriorated LBP are presented in Section 4.2. Under the Lead Safe Housing Rule, LBP is considered to be deteriorated if there is any deterioration. It is considered here to be significantly deteriorated if the deterioration exceeds the *de minimis* thresholds given in the definition of a significant LBP hazard presented in Chapter 3.

4.1 Prevalence of Lead-Based Paint

An estimated 38 million (±3 million[28]) or 40 percent (±4%) of housing units (HUs) in the United States have LBP on either the interior or exterior painted surfaces, or both. Table 4.1 presents the number and percentage of housing units with LBP by selected characteristics, including year of construction, geographic region, degree of urbanization, presence of children under age 6, tenure, income, government support, race, ethnicity, and poverty.

As expected, older homes are more likely to have LBP than newer homes. An estimated 24 percent (±6%) of homes built between 1960 and 1977 have LBP, but the percentage increases to 69 percent (±9%) for homes built between 1940 and 1959, and to 87 percent (±5%) for homes built before 1940. Table 4.1 indicates that only 7 percent (±5%) of homes built after 1977 have LBP. This estimate may be somewhat high because HU age is based on the residents' reports. Some residents, especially renters, may have reported their homes as being newer than they actually are. There were a few homes in the survey in which an examination of all of the data collected from a home presented a picture that suggested that the home may be older than reported by the respondent. In no case was the respondent's reported age overridden in the analyses.

Table 4.1 Prevalence of Lead-Based Paint (LBP) by Selected Housing Unit (HU) Characteristics

[28] All confidence intervals are at the 95% level for the estimated number or percent.

HU Characteristic	All HUs (000)	Number of HUs with LBP (000)			Percent of HUs with LBP (%)[1]			HUs in Sample
		Estimate	Lower 95% CI[2]	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Total Housing Units[3]	95,688	37,897	34,521	41,272	40%	36%	43%	831
Construction Year:								
1978-1998	29,774	2,031	620	3,441	7%	2%	12%	220
1960-1977	27,874	6,577	4,875	8,280	24%	18%	30%	267
1940-1959	20,564	14,171	12,203	16,139	69%	60%	77%	186
Before 1940	17,476	15,117	13,532	16,702	87%	82%	91%	158
Region:								
Northeast	19,290	10,600	8,306	12,895	55%	46%	64%	155
Midwest	22,083	11,748	10,546	12,950	53%	48%	59%	196
South	35,474	9,607	7,762	11,451	27%	22%	32%	277
West	18,841	5,942	4,747	7,137	32%	25%	38%	203
Urbanization:								
MSA equal or above 1 million population	26,814	9,681	7,550	11,812	36%	30%	42%	276
MSA below 1 million population	45,753	17,390	14,026	20,754	38%	32%	44%	417
Non-MSA	23,121	10,826	7,458	14,193	47%	35%	59%	138
Housing Unit Type:								
Single family	82,651	34,081	30,874	37,289	41%	37%	45%	705
Multi-family	13,037	3,815	2,470	5,160	29%	20%	39%	126
Tenure:								
Owner-occupied	66,232	25,172	22,400	27,943	38%	35%	41%	539
Renter-occupied	29,074	12,409	9,538	15,281	43%	35%	50%	289
Refusal/Don't Know[4]	381							3
Income:								
Less than $30,000/year	33,830	15,007	11,604	18,411	44%	37%	52%	309
Equal to or more than $30,000/year	56,111	20,815	17,745	23,885	37%	32%	42%	482
Refusal/Don't Know	5,747							40
One or More Children Under Age 6								
All Income Categories	16,402	5,328	4,048	6,609	32%	26%	39%	184
Less than $30,000/year	4,791	1,375	784	1,965	29%	16%	41%	61
Equal to or more than $30,000/year	11,236	3,820	2,579	5,061	34%	23%	45%	117
Refusal/Don't Know	375				36%			6
One or More Children Under Age 6:								
All HU Ages	16,402	5,328	4,048	6,609	32%	26%	39%	184
HUs built 1978-1998	5,847	202	0	436	3%	0%	7%	56
HUs built 1960-1977	5,098	876	416	1,337	17%	8%	26%	61
HUs built 1940-1959	3,055	1,997	1,341	2,654	65%	44%	87%	40
HUs built before 1940	2,401	2,253	1,426	3,079	94%	59%	100%	27

Table 4.1 Prevalence of Lead-Based Paint (LBP) by Selected Housing Unit (HU) Characteristics (continued)

HU[3] Characteristic	All HUs (000)	Number of HUs with LBP (000)			Percent of HUs with LBP (%)[1]			HUs in Sample
		Estimate	Lower 95% CI[2]	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Government Support:								
Government support	4,809	1,741	678	2,805	36%	16%	56%	54
No government support	86,070	33,871	30,681	37,062	39%	36%	43%	733
Refusal/Don't Know	4,809							44
Race:								
White	77,005	30945	28037	33853	40%	37%	44%	622
African American	10,365	4,228	2,767	5,689	41%	30%	52%	116
Other[5]	6,571	1,913	1,015	2,811	29%	17%	41%	77
Unknown	1,746	811			46%			16
Ethnicity:								
Hispanic/Latino	7,434	3,329	2,044	4,614	45%	31%	59%	86
Not Hispanic/Latino	87,008	33,830	30,436	37,223	39%	35%	42%	736
Refusal/Don't Know	1,246							9
Poverty by Urbanization:								
MSA equal or above 1 Million population								
In poverty	2,962	1,205	735	1,674	41%	25%	57%	35
Not in poverty	22,005	7,758	5,957	9,559	35%	27%	43%	226
MSA below 1 million Population								
In poverty	6,996	3,795	2,248	5,341	54%	32%	76%	75
Not in poverty	35,786	12,455	9,722	15,188	35%	27%	42%	323
Non-MSA								
In poverty	3,264	1,362	310	2,414	42%	9%	74%	27
Not in poverty	18,544	8,684	5,071	12,297	47%	27%	66%	102
Refusal/Don't Know if in Poverty	6,131							43

[1] All percentages are calculated with the "all HUs" on the left most column of each row as the denominator.

[2] CI = 95% confidence interval for the estimated number or percent.

[3] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[4] Refusals and "don't know" responses by survey respondents.

[5] "Other" race includes Asian, American Indian or Alaskan Native, Native Hawaiian or other Pacific Islander, and more than one race.

The data also suggest that homes in northeastern and midwestern states are more likely to have LBP than homes in southern or western states. An estimated 55 percent and 53 percent of homes in the Northeast and Midwest have LBP, while the estimates are 27 percent and 32 percent for homes in the South and West, respectively. This finding can be explained by the fact that homes in the Northeast and Midwest are older.

An estimated 5.3 million (±1.3 million) or 32 percent (± 6%) of homes with children under the age of 6 years have lead-based paint, although children are eligible to live in 38 million homes with lead-based paint. Homes with children under age 6 showed the same relationship between HU age and the presence of LBP as do all homes.

The differences among LBP prevalence by urbanization, single family versus multi-family housing, occupant status, household income, race, ethnicity, and poverty crossed with urbanization do not appear to be significant in that the confidence intervals overlap. Likewise, there were no differences in LBP prevalence when urbanization was crossed by construction year, or one or more children under age 6 was crossed by construction year. Thus, these cross-comparisons are not presented in Table 4.1.

Table 4.2 presents the number of homes with LBP by location in the building – either interior or exterior, or both. About one-half of homes with lead-based paint have it on both interior and exterior surfaces (21% of all homes, or 53% of homes with LBP anywhere in the building).

Table 4.2 Prevalence of Lead-Based Paint (LBP) by Location in the Building

LBP Location	Number of HUs[1] with LBP (000)			Percent of HUs with LBP (%)[2]			HUs in Sample
	Estimate	Lower 95% CI[3]	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Interior Only	8,609	6,102	11,116	9%	6%	12%	77
Both Interior and Exterior	20,260	17,961	22,558	21%	19%	24%	181
Exterior Only	9,028	6,535	11,521	9%	7%	12%	80
Subtotal – LBP anywhere in Building	37,897	34,521	41,272	40%	36%	43%	338
No LBP in Building	57,791	54,624	60,959	60%	57%	64%	493
Total HUs	95,688			100%			831

[1] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[2] All percentages are calculated with total housing units (95,688) as the denominator. Percentages may not total 100% due to rounding.

[3] CI = 95% confidence interval for the estimated number or percent.

4.2 Prevalence of Deteriorated Lead-Based Paint

Although there are many homes with LBP, the condition of the paint is important in determining whether a hazard exists. Except during renovations, maintenance, or other activities that could disturb it, intact lead-based paint is believed to pose little immediate risk to occupants. However, significantly deteriorated lead-based paint may present an immediate danger to occupants, especially to young children. Table 4.3 presents the number and percentage of HUs with deteriorated LBP and significantly deteriorated LBP by location in the building - either interior or exterior, or both.

Table 4.3 Prevalence of Deteriorated and Significantly Deteriorated Lead-Based Paint (LBP) by Location in the Building

a. Deteriorated LBP							
Location	**Number of HUs[1] with Deteriorated LBP (000)**			**Percent[2] of HUs with Deteriorated LBP(%)**			**HUs in Sample**
	Estimate	**Lower 95% CI[3]**	**Upper 95% CI**	**Estimate**	**Lower 95% CI**	**Upper 95% CI**	
Interior Only	4,180	2,851	5,509	4%	3%	6%	39
Both Interior and Exterior	6,236	4,661	7,811	7%	5%	8%	62
Exterior Only	7,009	4,922	9,097	7%	5%	10%	61
Total with Deteriorated LBP	17,425	14,816	19,735	18%	15%	21%	162
No Deteriorated LBP	78,263	75,953	80,572	82%	79%	84%	669
TOTAL	95,688			100%			831
b. Significantly Deteriorated LBP							
Location	**Number of HUs[1] with Significant Deteriorated LBP (000)**			**Percent[2] of HUs with Significant Deteriorated LBP(%)**			**HUs in Sample**
	Estimate	**Lower 95% CI[3]**	**Upper 95% CI**	**Estimate**	**Lower 95% CI**	**Upper 95% CI**	
Interior Only	2,629	1,692	3,566	3%	2%	4%	28
Both Interior and Exterior	3,487	2,132	4,842	4%	2%	5%	34
Exterior Only	7,518	5,357	9,679	8%	6%	10%	65
Total with Significantly Deteriorated LBP	13,634	10,928	16,341	14%	11%	17%	127
No Significantly Deteriorated LBP	82,053	79,347	84,760	86%	83%	89%	704
TOTAL	95,688			100%			831

[1] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[2] Percentages are calculated with total housing units (95,688) as the denominator. Percentages may not total 100% due to rounding.

[3] CI = 95% confidence interval for the estimated number or percent.

An estimated 17 million (±2 million) or 18 percent (±2%) of housing units in the United States have deteriorated LBP. The deteriorated LBP is only on the exterior for approximately 40 percent of the homes with deteriorated LBP. An estimated 14 million (±3 million) or 14 percent (±3%) of housing units in the United States have *significantly* deteriorated LBP. Roughly 55 percent of these homes have significant deterioration only on exterior surfaces. Twenty percent of these homes have the significantly deteriorated LBP only on interior surfaces.

Table 4.4 presents the number and percentage of housing units with deteriorated and significantly deteriorated LBP by construction year. The data suggest that older homes are more likely to have deteriorated LBP than newer homes. Only 3% of homes built between 1960 and 1977 have deteriorated LBP, but the percentage increases to 32% for homes built between 1940 and 1959, and to 56% for homes built before 1940. Only 2% of homes built between 1960 and 1977 have deteriorated LBP, but the percentage increases to 25% for homes built between 1940 and 1959, and to 44% for homes built before 1940.

Table 4.4 Distribution of Housing Units (HUs) with Deteriorated and Significantly Deteriorated Lead-Based Paint (LBP) by Construction Year

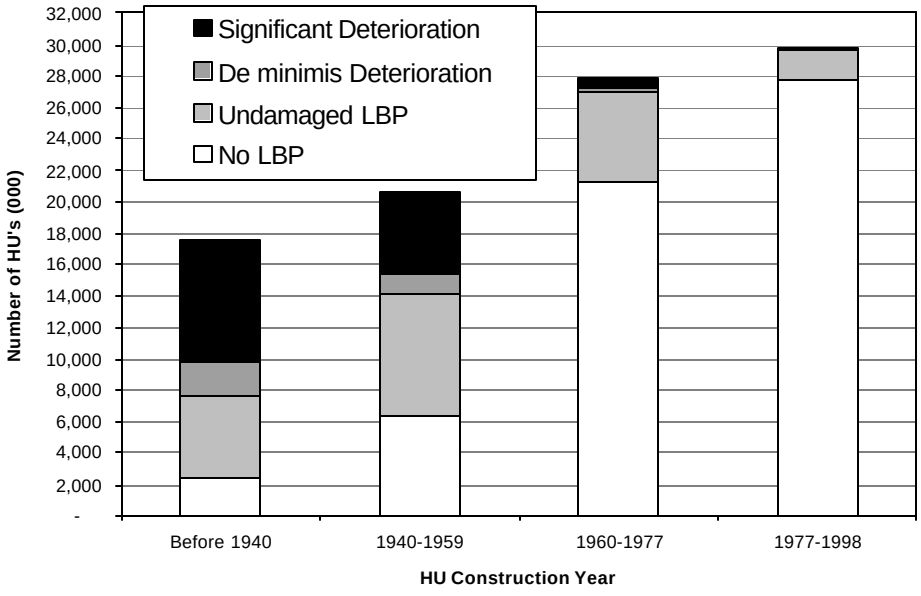
a. Deteriorated LBP							
Construction Year	**Total HUs (000)[2]**	**Number of HUs with Deteriorated LBP (000)**			**Percent of HUs with Deteriorated LBP (%)[1]**		
		Estimate	**Lower 95% CI[3]**	**Upper 95% CI**	**Estimate**	**Lower 95% CI**	**Upper 95% CI**
1978-1998	29,774	139	0	330	0%	0%	1%
1960-1977	27,874	910	235	1,586	3%	1%	6%
1940-1959	20,564	6,510	4,603	8,418	32%	22%	41%
Before 1940	17,476	9,866	8,111	11,620	56%	46%	66%
Total HUs	95,688	17,425	15,222	19,628	18%	16%	21%
b. Significantly Deteriorated LBP							
Construction Year	**Total HUs (000)[2]**	**No. of HUs with Significantly Deteriorated LBP (000)**			**Percent of HUs with Significantly Deteriorated LBP (%)[1]**		
		Estimate	**Lower 95% CI[3]**	**Upper 95% CI**	**Estimate**	**Lower 95% CI**	**Upper 95% CI**
1978-1998	29,774	83	0	238	0%	0%	1%
1960-1977	27,874	610	97	1,122	2%	0%	4%
1940-1959	20,564	5,190	3,387	6,993	25%	16%	34%
Before 1940	17,476	7,752	6,048	9,456	44%	35%	54%
Total HUs	95,688	13,635	9,893	16,582	14%	10%	17%

[1] Percentages may not total 100% due to rounding.

[2] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.
[3] CI = 95% confidence interval for the estimated number or percent.

Figure 4.1 is a bar chart that summarizes the survey data on deteriorated and significantly deteriorated LBP by construction year.

Figure 4-1. Presence and Condition of LBP by Construction Year



4.3 Paint Lead Loadings in Housing

Table 4.5 presents the distribution of the highest lead paint loading by location in the building for selected thresholds: 0.3, 0.6, 0.8, 1.0, 1.3, 4.0, and 10.0 mg/cm^2. By definition, paint with less than 1.0 mg/cm^2 is not LBP; thus, the first four categories represent paint that is considered not to be LBP. The majority of the surfaces tested did not contain lead-based paint: In 70 percent of HUs the highest interior readings, and in 69 percent of HUs the highest exterior readings were below 1.0 mg/cm^2. Fourteen percent of HUs had at least one paint sample with 10 mg/cm^2 or more of lead-based paint.

Table 4.5 Distribution of Paint Lead Loading by Location in the Building

Maximum Paint Lead Loading in HU[3]	Interior (% HUs)[1]			Exterior (% HUs)			Anywhere (% HUs)		
	Estimate	Lower 95% CI[2]	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI
LT 0.3 mg/cm^2	49%	44%	53%	58%	54%	61%	38%	33%	42%
LT 0.6 mg/cm^2	63%	61%	66%	65%	62%	68%	53%	50%	56%
LT 0.8 mg/cm^2	68%	66%	71%	67%	64%	71%	58%	55%	61%
LT 1.0 mg/cm^2	70%	67%	73%	69%	66%	73%	60%	57%	64%
LT 1.3 mg/cm^2	74%	71%	76%	71%	67%	74%	64%	60%	67%
LT 4.0 mg/cm^2	83%	80%	86%	82%	78%	85%	76%	73%	80%
LT 10.0 mg/cm^2	91%	88%	93%	89%	87%	92%	86%	83%	89%
GE 10.0 mg/cm^2	9%	7%	12%	11%	8%	13%	14%	11%	17%
TOTAL Hus	100%			100%			100%		

[1] All percentages are calculated with total housing units (95,688) as the denominator. "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.
[2] CI = 95% confidence interval for the estimated number or percent.
[3] LT equals "less than." GE equals "greater than or equal to."

Table 4.6 presents the distribution of paint lead loadings by location in the building and construction year for the selected thresholds. This clearly demonstrates the effectiveness of the reduction from 1940 to 1980 in the amount of lead added to commercial residential paint. Thirteen percent of housing reported as built before 1940 had all lead samples anywhere in the house under 1.0 mg/cm^2 but this increased to 76 percent of housing reported as built between 1960 and 1977, and 93 percent of housing reported as built since 1978. The same pattern holds for very high lead levels, with 55 percent of pre-1940 homes having some lead above 10 mg/cm^2 but only 1 percent for post-1977 housing.[29] These differences would be even greater but for major paint removals, renovations, demolitions of older houses, and other causes of elimination of old paint.

[29] It should be noted that the 1 percent of homes built in 1978-1998 with a maximum paint lead loading above 10.0 mg/cm^2 may be a result of respondent error in reporting the date of home construction. Where a year was reported by the respondent, it was not modified.

Table 4.6 Distribution of Paint Lead Loading by Location in the Building and Construction Year

Percent of HUs with LBP[1-2]					
Largest Paint Lead Loading in the Housing Unit	**Year of Construction**				
	1978-1998	**1960-1977**	**1940-1959**	**Before 1940**	**Subtotal**
Interior					
LT 0.3 mg/cm^2	77%	61%	23%	9%	49%
LT 0.6 mg/cm^2	91%	79%	41%	17%	64%
LT 0.8 mg/cm^2	94%	84%	52%	20%	69%
LT 1.0 mg/cm^2	96%	84%	54%	21%	70%
LT 1.3 mg/cm^2	97%	88%	59%	28%	74%
LT 4.0 mg/cm^2	99%	94%	81%	40%	83%
LT 10.0 mg/cm^2	99%	98%	93%	62%	91%
GE 10.0 mg/cm^2	1%	2%	7%	38%	9%
TOTAL	100%	100%	100%	100%	100%
Exterior					
LT 0.3 mg/cm^2	89%	69%	31%	19%	58%
LT 0.6 mg/cm^2	93%	82%	36%	24%	65%
LT 0.8 mg/cm^2	95%	84%	39%	27%	67%
LT 1.0 mg/cm^2	97%	87%	41%	28%	69%
LT 1.3 mg/cm^2	97%	89%	44%	29%	70%
LT 4.0 mg/cm^2	100%	94%	72%	44%	81%
LT 10.0 mg/cm^2	100%	98%	90%	59%	89%
GE 10.0 mg/cm^2	0%	2%	10%	41%	11%
TOTAL	100%	100%	100%	100%	100%
Anywhere in Building					
LT 0.3 mg/cm^2	70%	43%	11%	5%	38%
LT 0.6 mg/cm^2	85%	69%	20%	11%	53%
LT 0.8 mg/cm^2	90%	74%	30%	12%	58%
LT 1.0 mg/cm^2	93%	76%	31%	13%	60%
LT 1.3 mg/cm^2	94%	82%	35%	16%	63%
LT 4.0 mg/cm^2	99%	90%	66%	27%	75%
LT 10.0 mg/cm^2	99%	97%	86%	45%	85%
GE 10.0 mg/cm^2	1%	3%	14%	55%	15%
TOTAL	100%	100%	100%	100%	100%

[1] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[2] LT equals "less than." GE equals "greater than or equal to."

Figures 4.2 through 4.4 are a series of boxplots of the distributions of the paint lead measurements recorded in the survey. Figure 4.2 shows the distribution of the lead in paint measurements by room type: kitchen, common living area (e.g., living room, den), bedroom, other room (e.g., bathroom,

office), and exterior.[30] Overall, the largest lead in paint readings were taken on the exterior of the homes. Of interior rooms, the kitchen had the highest lead in paint readings. Figure 4.3 shows the distribution of the lead in paint measurements by interior component type. The largest interior lead in paint readings were taken on window, door, and trim components. Figure 4.4 shows the distribution of the lead in paint measurements by exterior component type. The largest exterior lead in paint readings were taken on window and other components. The other category included chimneys and miscellaneous painted components purposively selected by the technician in addition to the required components.

Tables 4.7 and 4.8 present selected parameters of the distributions of paint lead loadings by interior and exterior component types, corresponding to the boxplots in Figures 4.2 and 4.3, respectively. Tables 4.7 and 4.8 also present the geometric means and standard deviations. All of the distributions in Tables 4.7 and 4.8 are right-skewed and thus cannot be fitted by normal distributions. A better model would be the lognormal distribution. Chapter 7 includes a discussion of fitting models to these data.

Table 4.7 Estimated Empirical Distribution Parameters of Paint Lead Loadings by Interior Component Types

	Walls, Floors, Ceilings	Windows	Doors	Trim	Other
	mg/cm^2	mg/cm^2	Mg/cm^2	mg/cm^2	mg/cm^2
Arithmetic Mean	0.2	0.9	0.6	0.5	0.4
Arithmetic Standard Deviation	1.5	3.4	2.5	2.3	2.6
Geometric Mean	0.1	0.1	0.1	0.1	0.1
Geometric Standard Deviation[1]	2.3	4.5	3.4	3.2	2.8
25^{th} Percentile	0.0	0.0	0.0	0.0	0.0
Median	0.0	0.0	0.0	0.0	0.0
75^{th} Percentile	0.0	0.1	0.0	0.0	0.0
90^{th} Percentile	0.1	1.3	0.4	0.2	0.2
95^{th} Percentile	0.3	6.0	1.9	1.4	0.5
Number of Readings	14,876	5,513	4,596	2,578	2,686

[1] The geometric standard deviation is computed as exp(s), where s is the arithmetic standard deviation of the natural logarithms of the loadings (see, e.g., Gilbert, R. O. (1987) *Statistical Methods for Environmental Pollution Monitoring*, Van Nostrand Reinhold Company New York).

[30] Paint and dust lead loading data is presented in box plot form. Each boxplot shows a univariate data distribution, for example, the dust samples collected from a specific location (e.g.,, entrance floor). The box in the boxplot represents the middle 50 percent of the data; the bottom of the box gives the 25th percentile; the top gives the 75th percentile; and the horizontal line inside the box gives the median or 50th percentile. The vertical lines extending from the top and bottom of the box reach to the largest and smallest observations, respectively, except for outliers. Outliers are not plotted. Data sets approximating a normal distribution will produce a symmetrical boxplot. From this display of the data, it is possible to visually compare lead loadings in all of the sample locations inside the dwellings simultaneously.

Table 4.8 Estimated Empirical Distribution Parameters of Paint Lead Loadings by Exterior Component Types

	Walls	Windows	Doors	Trim	Porch	Other
	mg/cm²	mg/cm²	Mg/cm²	Mg/cm²	mg/cm²	mg/cm²
Arithmetic Mean	0.9	2.6	1.3	1.1	1.1	1.6
Arithmetic Standard Deviation	3.4	6.1	4.4	4.5	3.9	5.0
Geometric Mean	0.1	0.3	0.1	0.1	0.1	0.2
Geometric Standard Deviation[1]	4.8	8.2	5.4	5.0	5.1	6.3
25th Percentile	0.0	0.0	0.0	0.0	0.0	0.0
Median	0.0	0.0	0.0	0.0	0.0	0.0
75th Percentile	0.1	1.7	0.1	0.1	0.1	0.3
90th Percentile	1.0	7.7	2.4	1.8	2.2	3.3
95th Percentile	4.8	15.3	7.4	5.4	7.8	10.7
Number of Readings	2,008	781	1,398	446	698	250

[1] The geometric standard deviation is computed as exp(s), where s is the arithmetic standard deviation of the natural logarithms of the loadings (see, e.g., Gilbert, R. O. (1987) *Statistical Methods for Environmental Pollution Monitoring*, Van Nostrand Reinhold Company New York).

Figure 4.2 Box Plots for Paint Lead (XRF) Measurements by Room Type

Figure 4.3 Box Plots for Paint Lead (XRF) Measurements by Interior Components

Figure 4.4 Box Plots for Paint Lead (XRF) Measurements by Exterior Components

4.4 Comparison of Prevalence of Lead-Based Paint (LBP) to the 1990 LBP Survey

Table 4.9 compares the prevalence of LBP and deteriorated LBP found in the National Survey (restricted to pre-1980 construction) with the prevalence found in the 1990 LBP Survey, which was similarly restricted[31]. The National Survey shows fewer total homes built before 1980. This is partly due to the fact that housing where children could not live was excluded from the current survey. There has also been a loss of homes built before 1980 due to demolition.

A lower percentage of pre-1980 homes were found with LBP during the current National Survey (50% versus 83% found in 1990). This was not unexpected because there has been renovation, remodeling, demolition, and paint removal activities in the intervening years.

Approximately the same percentage of homes with LBP had deteriorated LBP in both surveys (22% versus 19% found in 1990). The slight increase in the percentage of homes with deteriorated LBP was expected, because homes are now ten years older. In addition, the definitions of deteriorated LBP were different for the two studies. In the 1990 LBP Survey, deteriorated interior LBP was defined as more than 5 square feet of deteriorated interior lead-based paint, with a similar definition for exterior lead-based paint. Table 4.9 uses the 1995 HUD *Guidelines* definition of deteriorated LBP, as given in Chapter 3, for the comparison.

Table 4.9 Comparison of the Prevalence of Lead-Based Paint[1] to the 1990 LBP Survey

	1990 LBP Survey		Current National Survey (Pre-1980 HUs)	
	Number (000)	Percent (%)	Number (000)	Percent (%)
Total HUs Built Before 1980	77,177	100%	68,756	100%
HUs with LBP	64,059	83%	34,195	50%
Interior LBP	48,986	63%	26,184	38%
Exterior LBP	56,495	73%	27,373	40%
HUs with Deteriorated LBP[1]	14,354	19%	14,962	22%
Interior Deteriorated LBP	5,596	7%	7,281	11%
Exterior Deteriorated LBP	9,657	13%	11,784	17%

[1] Deteriorated LBP is as defined in the 1995 *Guidelines*.

[31] A comparison of the protocols for the two surveys is presented in Appendix B.

4.5 Amount of Lead-Based Paint in Housing

Table 4.10 presents estimates of the amounts of LBP by architectural component type. An estimated 7.4 billion square feet of painted interior surfaces are covered with LBP. This represents 2 percent of the area of painted interior surfaces in all homes. Although 2 percent of paint on walls, floors, and ceilings is lead-based, the area of these LBP-coated components accounts for 67 percent of all interior surfaces with LBP.[32] Conversely, paint on window and door system components is more likely to contain LBP, but the total surface area of LBP on these components is only 21 percent of the area of all interior painted surfaces.

An estimated 29.2 billion square feet of painted exterior surfaces are covered with LBP. This represents 22 percent of the area of painted exterior surfaces in all homes. Wall siding accounts for most (67%) of the surface area of LBP.

Although a large number of homes have LBP, most of them have relatively small areas of LBP. The average home has 259 square feet of interior LBP and 996 square feet of exterior LBP.

Table 4.10 Amount of LBP by Painted Component

Component	National Total Amount of LBP		Average Amount LBP Per Housing Unit with LBP (square feet)
	Millions of sq ft	Percent of All Paint on Component	
INTERIOR:			
Wall, Floor, Ceiling	4,993	2%	173
Window	687	9%	24
Door	911	6%	32
Trim	499	5%	17
Cabinets, Chimney, Beams	388	2%	13
TOTAL	7,448	2%	259
EXTERIOR:			
Wall	26,706	18%	912
Window	365	28%	12
Door	446	14%	15
Trim	556	12%	19
Porch	1,086	21%	37
TOTAL	29,159	22%	996

[32] For comparison, a room 10 feet by 12 feet with an 8 foot ceiling has a wall area of 352 square feet and a combined wall, ceiling and floor area of 592 square feet.

5. DUST LEAD IN HOUSING

Chapter 5 presents estimates of the prevalence of lead-contaminated dust in housing, including the dust lead loadings and the association between interior dust lead and exterior LBP condition. No comparison is made with the dust lead findings of the 1990 LBP Survey because the vacuum technique employed in the earlier study is not comparable to the wipe technique used in the National Survey. All estimates in this chapter are based on the full, weighted sample of 831 housing units.

5.1 Prevalence of Dust Lead in Housing

Table 5.1 presents the prevalence of all homes and homes with one or more children under 6 years of age with a dust lead hazard somewhere in the home,[33] as defined by the HUD Lead Safe Housing Rule. The HUD Lead Safe Housing Rule defines a dust lead hazard as greater than or equal to 40 µg/ft² lead on floors or 250 µg/ft² lead on window sills. There is no longer a hazard level defined for dust lead on window troughs. The earlier HUD 1995 *Guidelines* considered lead in dust to be a hazard when dust on floors had greater than 100 µg/ft² lead, dust on window sills had greater than 500 µg/ft² lead, or dust on window troughs had greater than 800 µg/ft² lead.

Using the HUD Lead Safe Housing Rule definition of dust lead hazard, an estimated 16 percent (±2%[34]) of all homes have a dust lead hazard somewhere in the home, and 3 percent (±1%) of all homes have both a child under 6 years of age and a dust lead hazard.

[33] The maximum lead dust loading on any surface tested (floor, window sill, and window trough) in the home was used to determine whether a dust lead hazard existed.

[34] All confidence intervals are at the 95 percent level for the estimated number or percent.

Table 5.1 Prevalence of Housing Units with a Dust Lead Hazard Somewhere in the Home

HU Category[1]	Number of HUs (000)			Percent of HUs(%)[2]		
	Estimate	Lower 95% CI[3]	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI
HUs with Lead Dust Hazard	15,021	12,424	17,617	16%	13%	18%
HUs with Children Under 6 Years and Lead Dust Hazard	2,551	1,515	3,587	16%	9%	22%

[1] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[2] All percentages are calculated with total housing units (95,688) or HUs with resident children under age 6 (16,402) as the denominator.

[3] CI = 95% confidence interval for the estimated number or percent.

5.2 Dust Lead Loadings in Housing

Tables 5.2a and 5.2b present information on maximum and average dust loadings, respectively, by surface.

Table 5.2a presents the distribution of maximum dust lead loadings by surface (floor, window sill, and window trough) for all U.S. homes in the target population, for selected threshold values. As for Table 5.1, the estimates are based on the maximum dust lead loading in the home for the particular surface.

Only an estimated 6 percent of all homes have maximum floor dust lead loadings above the HUD Lead Safe Housing Rule interim standard of 40 µg/ft^2.[35] More homes have a window sill lead dust hazard than have a floor dust hazard. An estimated 14 percent of all homes have sill dust lead loadings above the HUD Lead Safe Housing Rule interim standard hazard of 250 µg/ft^2.[36]

[35] The average analytical detection limit for each wipe sample was 3.5 µg. While detection limits for each surface are area dependent, this corresponds to a detection limit of 3.5 µg/ft^2 for a one square foot floor sample, 7 µg/ft^2 for a typical 3 inch by 24 inch sill sample, or 8 µg/ft^2 for a typical 1 inch by 18 inch trough sample.

[36] From Table 5.2a, the percent of homes with sill dust loadings above 250 µg/ft^2 equals [100% (all homes) - 82% (homes with lead in sill dust below 250 µg/ft^2) - 2% (homes with missing data) - 2% (homes with no sills)] = 14%.

Table 5.2a Distribution of Maximum Dust Lead Loadings by Surface

Maximum Dust Lead Loading in HU (µg/sq ft)	Number of HUs (000)[1]			Percent of HUs (%)[2]		
	Estimate	Lower 95% CI[4]	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI
Floors:[3]						
LT LOD[5]	39,120	35,097	43,144	41%	37%	45%
LT 5	67,937	64,284	71,590	71%	68%	74%
LT 10	80,016	76,773	83,260	84%	81%	87%
LT 20	86,813	83,999	89,627	91%	89%	93%
LT 40	90,308	87,586	93,029	94%	93%	96%
LT 100	93,305	90,976	95,633	98%	95%	100%
GE 100	2,260	1,326	3,194	2%	1%	3%
Missing[6]	123			0%		
Window Sills:						
LT LOD	10,081	7,775	12,387	11%	8%	13%
LT 125	71,563	68,323	74,804	75%	72%	78%
LT 250	78,462	75,463	81,462	82%	79%	85%
LT 500	82,884	80,060	85,707	87%	84%	89%
GE 500	8,853	6,968	10,738	9%	7%	11%
No sill present in HU[7]	2,221	848	3,594	2%	1%	4%
Missing[6]	1,731			2%		
Window Troughs:						
LT LOD	374	0	799	0%	0%	1%
LT 400	44,305	39,365	49,246	46%	41%	51%
LT 800	51,701	45,737	57,666	54%	48%	60%
GE 800	20,896	16,305	25,486	22%	17%	27%
No trough present in HU	7,318	5,176	9,459	8%	5%	10%
Missing[6]	15,773			16%		

[1] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[2] All percentages are calculated with total housing units (95,688) as the denominator.

[3] Floors include both carpeted and uncarpeted floors.

[4] CI = 95% confidence interval for the estimated number or percent.

[5] LT equals "less than." GE equals "greater than or equal to." LOD equals "limit of detection."

[6] Missing means that the floor, sill, or trough was present, but that no lead value is available (either the sample was not collected, e.g., due to inaccessibility or respondent refusal, or the laboratory did not submit a value).

[7] "No sill/trough present" means that there was no sill or trough in the HU, e.g., windows were flush with the wall, or awning windows were installed.

An estimated 22 percent of homes have window trough dust lead above the HUD *Guidelines* for hazard of 800 µg/ft^2. This finding supports conclusions from other dust lead studies that suggest window troughs typically have the highest dust lead loadings found in a home.

Table 5.2b presents the distribution of average dust lead loadings by surface (floor, window sill, and window trough) for all U.S. homes in the target population, for selected threshold values. The average dust loading for each surface was determined by simply adding floor, window sill, or window trough dust loadings for each room sampled in each HU and dividing by the number of rooms sampled (unweighted average).[37] This is not how either the HUD Lead Safe Housing Rule or the 1995 *Guidelines* define a lead dust hazard. Instead, it gives an estimate of whether the entire house has a hazardous level of lead-contaminated dust, as opposed to any one location in the house.

The same trends are observed in Table 5.2b for average dust lead loadings as for the distribution of maximum dust lead loadings in Table 5.2a. However, Table 5.2b shows that fewer homes have carpeted floor dust lead hazards than uncarpeted floor dust hazards (i.e. carpeted floors have lower dust lead loadings – as indicated by the results of the wipe sampling employed in the survey).

Table 5.2c summarizes Tables 5.2a and 5.2b by presenting the percent of homes with a lead dust hazard by surface under the HUD 1995 *Guidelines* and under the HUD Lead Safe Housing Rule based on the maximum and average dust lead loadings.

[37] For averaging floor samples, only carpeted floor samples and uncarpeted floor samples were combined for the respective average (carpeted or uncarpeted).

Table 5.2b Distribution of Average Dust Lead Loadings by Surface

Average Dust Lead Loading in HU (µg/sq ft)	Number of HUs (000)[1]			Percent of HUs (%)[2]		
	Estimate	Lower 95% CI[3]	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI
Floors (Uncarpeted):						
LT LOD[4]	51,085	47,301	54,868	53%	49%	57%
LT 5	74,127	70,576	77,678	77%	74%	81%
LT 10	83,068	80,400	85,736	87%	85%	89%
LT 20	86,788	84,587	88,990	91%	89%	93%
LT 40	89,222	86,744	91,699	93%	91%	95%
LT 100	90,466	88,198	92,734	95%	93%	96%
GE 100	966	239	1,693	1%	0%	2%
Missing[5]	4,209			4%		
Floors (Carpeted):						
LT LOD	59,960	56,209	63,712	63%	59%	66%
LT 5	82,250	78,725	85,775	86%	83%	89%
LT 10	88,164	85,229	91,099	92%	90%	94%
LT 20	91,618	89,298	93,937	96%	95%	97%
LT 40	93,774	91,630	95,917	98%	97%	99%
LT 100	95,062	93,220	96,903	99%	99%	100%
GE 100	503	91	915	1%	0%	1%
Missing	77			0%		
Window Sills:						
LT LOD	13,221	10,689	15,753	14%	11%	17%
LT 125	78,061	74,748	81,374	82%	79%	84%
LT 250	83,502	80,659	86,344	87%	85%	90%
LT 500	86,942	84,336	89,549	91%	89%	93%
GE 500	4,794	3,507	6,082	5%	4%	6%
No sill present in HU[6]	2,221	848	3,594	2%	1%	4%
Missing	1,731			2%		
Window Troughs:						
LT LOD	849	259	1,439	1%	0%	2%
LT 400	48,208	43,809	52,617	50%	46%	55%
LT 800	56,256	50,900	61,613	59%	53%	64%
GE 800	16,341	12,779	19,903	17%	13%	21%
No trough present in HU	7,318	5,176	9.459	8%	5%	10%
Missing	15,773			16%		

[1] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[2] All percentages are calculated with total housing units (95,688) as the denominator.

[4] LT equals "less than." GE equals "greater than or equal to." LOD equals "limit of detection."

[5] Missing means that the floor, sill, or trough was present, but that no lead value is available (either the sample was not collected, e.g., due to inaccessibility or respondent refusal, or the laboratory did not submit a value).

[6] "No sill/trough present" means that there was no sill or trough in the HU, e.g., windows were flush with the wall, or awning windows were installed.

Table 5.2c Comparison of Dust Lead Hazards for the HUD 1995 *Guidelines* and the HUD Lead Safe Housing Rule

Surface	Estimate of HUs (%) with a Dust Lead Hazard - based on Maximum Dust Loading		Estimate of HUs (%) with a Dust Lead Hazard - based on Average Dust Loading in HU	
	HUD 1995 *Guidelines*	HUD Lead Safe Housing Rule	HUD 1995 *Guidelines*	HUD Lead Safe Housing Rule
Floor	2%	6%	1%	3%
Window sill	9%	14%	5%	13%
Window trough	22%	NA	17%	NA

NA – Not applicable

Table 5.3 presents the distribution of dust lead loadings by room type and surface for selected threshold values. The vast majority of floors had undetectable levels of dust lead. About 3 percent of rooms had dust lead levels above the HUD Lead Safe Housing Rule standard for floors. Five percent of rooms had dust lead levels above the Lead Safe Housing Rule standard for window sills.

Tables 5.4a through 5.4c present floor, window sill, and window trough dust lead loading, respectively, by selected thresholds and by year of construction. It is evident that older homes have considerably more dust lead than newer homes. The percentage of homes over the Rule standard of 40 :g/ sq ft for floor dust (Table 5.4a) increases from less than 1 percent for post-1977 homes to 16 percent for pre-1940 homes. The percentage of homes over the sill dust guidelines (Table 5.4b) steadily increases from 2 percent for post-1977 homes to 14 percent for 1940-1959 homes to 38 percent for pre-1940 homes.

Table 5.3 Distribution of Dust Lead Loading by Room and Surfaces

Dust Lead Loading (µg/sqft)[1]	Kitchens		Living Rooms		Bedrooms		Other Rooms	
	Number of Rooms (000)[2]	Percent of Rooms (%)[3]	Number of Rooms (000)	Percent of Rooms (%)	Number of Rooms (000)	Percent of Rooms (%)	Number of Rooms (000)	Percent of Rooms (%)
Floors[4]								
LT LOD[5]	63,244	66%	98,433	78%	133,895	62%	227,341	71%
LT 5	80,815	85%	115,302	91%	153,563	71%	277,488	87%
LT 10	89,310	94%	120,878	95%	158,921	73%	292,846	92%
LT 20	92,307	97%	123,341	97%	163,824	75%	300,420	94%
LT 40	94,166	99%	124,285	98%	165,853	76%	303,569	95%
LT 100	94,542	99%	124,994	98%	166,092	77%	310,261	97%
GE 100	335	0%	170	0%	1,354	0%	785	0%
Missing[6]	488	1%	1,737	1%	49,623	23%	7,910	2%
Total Rooms	95,365	100%	126,902	100%	217,069	100%	318,956	100%
Window Sills								
LT LOD	23,001	24%	29,378	23%	32,163	15%	43,363	14%
LT 125	66,357	70%	90,595	71%	124,599	57%	158,813	50%
LT 250	69,065	72%	94,801	75%	133,030	61%	165,128	52%
LT 500	70,939	74%	97,147	77%	135,119	62%	172,189	54%
GE 500	2,455	3%	4,386	3%	5,729	3%	10,096	3%
Missing	3,870	4%	5,462	4%	17,993	8%	16,321	5%
No Sills	18,102	19%	19,907	16%	58,230	27%	120,350	38%
Total Rooms	95,365	100%	126,902	100%	217,069	100%	318,956	100%
Window Troughs								
LT LOD	3,293	3%	4,125	3%	2,976	1%	5,698	2%
LT 800	44,005	46%	56,157	44%	82,441	38%	101,980	32%
800 and up	9,249	10%	12,795	10%	17,970	8%	21,311	7%
Missing	16,542	17%	27,537	22%	57,738	27%	58,044	18%
No Trough	25,568	27%	30,413	24%	58,920	27%	137,621	43%
Total Rooms	95,365	100%	126,902	100%	217,069	100%	318,956	100%

[1] In this table, maximum loading is not applicable as only one dust sample was collected from each surface in each room.

[2] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[3] All percentages are calculated with total rooms of that type as the denominator.

[4] Floors include both carpeted and uncarpeted floors.

[5] LT equals "less than." GE equals "greater than or equal to." LOD equals "limit of detection."

[6] Missing means that the floor, sill, or trough was present, but that no lead value is available (either the sample was not collected, e.g., due to inaccessibility or respondent refusal, or the laboratory did not submit a value).

Table 5.4a Maximum Floor Dust Lead Loading by Year of Construction

Maximum Floor Dust Lead Loading(µg/sq ft)[1]		Year of Construction							
		1978-1998		1960-1977		1940-1959		Before 1940	
		Number (000)	Percent (%)[2]	Number (000)	Percent (%)	Number (000)	Percent (%)	Number (000)	Percent (%)
LT LOD[3]	Number HUs[4]	17,853	60%	13,243	48%	5,816	28%	2,208	13%
	Lower 95% CI[5]	15,897	54%	10,488	38%	4,254	21%	783	4%
	Upper 95% CI	19,808	66%	15,999	57%	7,378	36%	3,634	21%
LT 5	Number HUs	26,926	90%	22,974	82%	11,805	57%	6,231	36%
	Lower 95% CI	25,531	87%	21,426	78%	9,890	50%	4,372	27%
	Upper 95% CI	28,322	94%	24,523	87%	13,721	65%	8,089	45%
LT 10	Number HUs	28,785	97%	25,455	91%	15,621	76%	10,156	58%
	Lower 95% CI	27,613	94%	24,110	88%	13,512	69%	8,065	49%
	Upper 95% CI	29,957	99%	26,800	94%	17,729	83%	12,247	67%
LT 20	Number HUs	29,632	100%	26,762	96%	17,940	87%	12,480	71%
	Lower 95% CI	28,638	99%	25,271	94%	15,866	81%	10,750	65%
	Upper 95% CI	30,626	100%	28,253	98%	20,013	94%	14,209	78%
LT 40	Number HUs	29,632	100%	27,286	98%	18,758	91%	14,632	84%
	Lower 95% CI	28,638	99%	25,872	97%	16,734	85%	12,835	79%
	Upper 95% CI	30,626	100%	28,699	99%	20,782	97%	16,430	89%
LT 100	Number HUs	29,632	100%	27,594	99%	19,717	96%	16,362	94%
	Lower 95% CI	28,638	99%	26,143	98%	17,902	92%	14,659	91%
	Upper 95% CI	30,626	100%	29,045	100%	21,532	100%	18,064	97%
GE 100	Number HUs	97	0%	280	1%	770	4%	1,114	6%
	Lower 95% CI	0	0%	0	0%	25	0%	587	3%
	Upper 95% CI	267	1%	640	2%	1,514	7%	1,642	9%
Missing	Number HUs	46	0%	0	0%	77	0%	0	0%

[1] Floors include both carpeted and uncarpeted floors.

[2] All percentages are calculated with total housing units (95,688) as the denominator.

[3] LT equals "less than." GE equals "greater than or equal to." LOD equals "limit of detection."

[4] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live

[5] CI = 95% confidence interval for the estimated number or percent.

Table 5.4b Maximum Window Sill Dust Lead Loading by Year of Construction

Maximum Window Sill Dust Lead Loading(µg/sq ft)[1]		Year of Construction							
		1978-1998		1960-1977		1940-1959		Before 1940	
		Number (000)	Percent (%)[2]	Number (000)	Percent (%)	Number (000)	Percent (%)	Number (000)	Percent (%)
LT LOD[3]	Number HUs[4]	6,405	22%	2,194	8%	1,074	5%	408	2%
	Lower 95% CI[5]	4,503	15%	966	4%	278	1%	0	0%
	Upper 95% CI	8,307	28%	3,422	12%	1,870	9%	835	5%
LT 125	Number HUs	26,478	89%	22,556	81%	14,446	70%	7,988	46%
	Lower 95% CI	24,693	84%	20,264	74%	12,475	63%	6,334	38%
	Upper 95% CI	28,263	94%	24,848	88%	16,417	77%	9,642	54%
LT 250	Number HUs	27,255	92%	24,898	89%	16,141	78%	10,073	58%
	Lower 95% CI	25,621	87%	23,334	86%	14,100	73%	8,268	51%
	Upper 95% CI	28,889	96%	26,461	93%	18,181	84%	11,878	65%
LT 500	Number HUs	27,837	93%	25,906	93%	16,984	83%	12,061	69%
	Lower 95% CI	26,354	90%	24,092	89%	14,985	77%	10,215	62%
	Upper 95% CI	29,320	97%	27,720	97%	18,983	88%	13,908	76%
GE 500	Number HUs	363	1%	747	3%	2,869	14%	4,874	28%
	Lower 95% CI	0	0%	275	1%	1,780	9%	3,611	21%
	Upper 95% CI	903	3%	1,219	4%	3,958	19%	6,137	35%
Missing	Number HUs	299	1%	851	3%	361	2%	220	1%
No sills	Number HUs	1,456	5%	371	1%	349	2%	45	0%
	Lower 95% CI	456	2%	0	0%	0	0%	0	0%
	Upper 95% CI	2,456	8%	762	3%	730	4%	143	1%

[1] Missing means that the sill or trough was present, but that no lead value is available (either the sample was not collected, e.g., due to inaccessibility or respondent refusal, or the laboratory did not submit a value). "No sill/trough present" means that there was no sill or trough in the HU, e.g., windows were flush with the wall, or awning windows were installed.

[2] All percentages are calculated with total housing units (95,688) as the denominator.

[3] LT equals "less than." GT equals "greater than or equal to." LOD equals "limit of detection."

[4] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live

[5] CI = 95% confidence interval for the estimated number or percent.

Table 5.4c Maximum Window Trough Dust Lead Loading by Year of Construction

Maximum Window Trough Dust Lead Loading (µg/sq ft)[1]		Year of Construction							
		1978-1998		1960-1977		1940-1959		Before 1940	
		Number (000)	Percent (%)[2]	Number (000)	Percent (%)	Number (000)	Percent (%)	Number (000)	Percent (%)
LT LOD[3]	Number HUs[4]	461	2%	94	0%	0	0%	0	0%
	Lower 95% CI[5]	0	0%	0	0%				
	Upper 95% CI	1,027	3%	235	1%				
LT 400	Number HUs	17,183	58%	14,263	51%	7,638	37%	5,222	30%
	Lower 95% CI	14,562	49%	11,645	42%	5,698	28%	3,640	21%
	Upper 95% CI	19,804	67%	16,880	61%	9,577	47%	6,804	39%
LT 800	Number HUs	18,986	64%	16,422	59%	9,970	48%	6,048	35%
	Lower 95% CI	15,983	54%	13,673	50%	7,638	39%	4,333	26%
	Upper 95% CI	21,988	74%	19,172	68%	12,301	58%	7,763	44%
GE 800	Number HUs	2,202	7%	3,788	14%	6,286	31%	8,619	49%
	Lower 95% CI	985	3%	2,505	9%	4,501	21%	6,826	40%
	Upper 95% CI	3,419	11%	5,071	18%	8,071	40%	10,413	59%
Missing	Number HUs	4,246	14%	6,088	22%	3,116	15%	2,322	13%
No troughs	Number HUs	4,341	15%	1,576	6%	1,191	6%	210	1%
	Lower 95% CI	2,382	8%	733	3%	369	2%	0	0%
	Upper 95% CI	6,299	21%	2,418	9%	2,013	10%	451	3%

[1] Missing means that the sill or trough was present, but that no lead value is available (either the sample was not collected, e.g., due to inaccessibility or respondent refusal, or the laboratory did not submit a value). "No sill/trough present" means that there was no sill or trough in the HU, e.g., windows were flush with the wall, or awning windows were installed.

[2] All percentages are calculated with total housing units of that age as the denominator.

[3] LT equals "less than." GT equals "greater than or equal to." LOD equals "limit of detection."

[4] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live

[5] CI = 95% confidence interval for the estimated number or percent.

Tables 5.5a through 5.5c present floor, window sill, and window trough dust loading distributions by household income level. There are some significant differences shown in the table. A greater percent of homes in the higher income level have lower lead dust loadings. For example, 48 percent of higher income homes have lead dust loadings below the limit of detection, while only 29 percent of homes in the lower income level have loading below the limit of detection. Only 1 percent of homes in the higher household income level exceed 100 µg/ft^2 floor dust lead loading, while 5 percent of lower income level homes exceed this loading. Similar trends are observed for window sill and trough dust loadings.

Although the data have not been presented, there were no apparent differences between urbanization categories and dust lead loadings.

Table 5.5a Maximum Floor Dust Lead Loadings by Household Income

Maximum Floor Dust Lead Loading(mg/sqft)[1]		Household Income			
		Less than $30,000/year		Equal to or above $30,000/year	
		Number (000)	Percent (%)[2]	Number (000)	Percent (%)
LT LOD[3]	Number HUs[4]	9,896	29%	26,902	48%
	Lower 95% CI[5]	7,091	23%	22,686	42%
	Upper 95% CI	12,702	35%	31,118	54%
LT 5	Number HUs	20,559	61%	43,043	77%
	Lower 95% CI	16,010	54%	38,953	73%
	Upper 95% CI	25,108	68%	47,134	80%
LT 10	Number HUs	25,581	76%	49,376	88%
	Lower 95% CI	20,616	70%	44,637	85%
	Upper 95% CI	30,545	81%	54,116	91%
LT 20	Number HUs	29,575	87%	51,898	92%
	Lower 95% CI	24,148	84%	47,321	90%
	Upper 95% CI	35,002	91%	56,476	95%
LT 40	Number HUs	31,038	92%	53,864	96%
	Lower 95% CI	25,518	88%	49,100	94%
	Upper 95% CI	36,559	95%	58,628	98%
LT 100	Number HUs	32,147	95%	55,598	99%
	Lower 95% CI	26,697	92%	51,108	98%
	Upper 95% CI	37,598	98%	60,088	100%
GE 100	Number HUs	1,637	5%	435	1%
	Lower 95% CI	729	2%	58	0%
	Upper 95% CI	2,545	8%	813	1%
Missing	Number HUs	46	0%	77	0%

[1] Missing means that the sill or trough was present, but that no lead value is available (either the sample was not collected, e.g., due to inaccessibility or respondent refusal, or the laboratory did not submit a value).

[2] All percentages are calculated with total housing units in that income class as the denominator.

[3] LT equals "less than." GT equals "greater than or equal to." LOD equals "limit of detection."

[4] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live

[5] CI = 95% confidence interval for the estimated number or percent.

Table 5.5b Maximum Window Sill Lead Dust Loadings by Household Income

Window Sill Dust Lead Loading(mg/sqft)[1]		Household Income			
		Less than $30,000/year		Equal to or Above $30,000/year	
		Number (000)	Percent[2]	Number (000)	Percent
LT LOD[3]	Number HUs[4]	1,448	4%	7,590	14%
	Lower 95% CI[5]	377	1%	5,651	10%
	Upper 95% CI	2,518	7%	9,530	17%
LT 125	Number HUs	21,336	63%	45,650	81%
	Lower 95% CI	17,252	58%	41,277	78%
	Upper 95% CI	25,420	69%	50,024	85%
LT 250	Number HUs	23,988	71%	49,743	89%
	Lower 95% CI	19,214	65%	45,159	86%
	Upper 95% CI	28,761	77%	54,328	91%
LT 500	Number HUs	27,182	80%	50,728	90%
	Lower 95% CI	21,834	76%	46,163	88%
	Upper 95% CI	32,530	85%	55,294	93%
GE 500	Number HUs	4,395	13%	3,704	7%
	Lower 95% CI	2,945	9%	2,640	5%
	Upper 95% CI	5,845	17%	4,768	8%
Missing	Number HUs	1,137	3%	594	1%
No sills	Number HUs	1,297	4%	809	1%
	Lower 95% CI	250	1%	151	0%
	Upper 95% CI	2,345	7%	1,466	3%

[1] Missing means that the sill or trough was present, but that no lead value is available (either the sample was not collected, e.g., due to inaccessibility or respondent refusal, or the laboratory did not submit a value). "No sill/trough present" means that there was no sill or trough in the HU, e.g., windows were flush with the wall, or awning windows were installed.

[2] All percentages are calculated with total housing units in that income class as the denominator.

[3] LT equals "less than." GT equals "greater than or equal to." LOD equals "limit of detection."

[4] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live

[5] CI = 95% confidence interval for the estimated number or percent.

Table 5.5c Maximum Window Trough Lead Dust Loadings by Household Income

Maximum Window Trough Dust Lead Loading(mg/sqft)[1]		Household Income			
		Less than $30,000/year		Equal to or Above $30,000/year	
		Number (000)	Percent[2]	Number (000)	Percent
LT LOD[3]	Number HUs[4]	239	1%	315	1%
	Lower 95% CI[5]	0	0%	0	0%
	Upper 95% CI	645	2%	722	1%
LT 400	Number HUs	13,064	39%	28,335	50%
	Lower 95% CI	9,925	29%	24,246	43%
	Upper 95% CI	16,203	48%	32,425	58%
LT 800	Number HUs	16,383	48%	31,780	57%
	Lower 95% CI	12,395	41%	27,222	50%
	Upper 95% CI	20,372	56%	36,338	63%
GE 800	Number HUs	9,449	28%	10,309	18%
	Lower 95% CI	6,745	20%	7,781	14%
	Upper 95% CI	12,153	36%	12,837	23%
Missing	Number HUs	5,836	17%	8,991	16%
No troughs	Number of HUs	2,162	6%	4,755	8%
	Lower 95% CI	870	3%	3,010	5%
	Upper 95% CI	3,454	10%	6,499	12%

[1] Missing means that the sill or trough was present, but that no lead value is available (either the sample was not collected, e.g., due to inaccessibility or respondent refusal, or the laboratory did not submit a value). "No sill/trough present" means that there was no sill or trough in the HU, e.g., windows were flush with the wall, or awning windows were installed.

[2] All percentages are calculated with total housing units in that income class as the denominator.

[3] LT equals "less than. "GE equals "greater than or equal to." LOD equals "limit of detection."

[4] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[5] CI = 95% confidence interval for the estimated number or percent.

Figure 5.1 shows the distribution of the dust lead loadings by room type: kitchen, common living area, bedroom, and other room. Figure 5.2 shows the distribution of the dust lead measurements by surface and carpet. In both figures, the distributions are extremely right-skewed. None of the boxes extend above 40 µg/ft^2, which means that the 75th percentile is less than 40 µg/ft^2. However, there are dust lead loadings well above 100 µg/ft^2. On troughs, they extend above 1,000 µg/ft^2 (not shown due to truncation of the vertical axis).

Table 5.6 presents selected parameters of the distributions of dust lead loadings by surface types, corresponding to the boxplots in Figure 5.2. Table 5.6 also presents geometric means and standard

deviations. The distributions in Table 5.6 are all right-skewed, so that they are not normally distributed. A better model would be the lognormal distribution. Chapter 7 includes a discussion of distributional models for these data.

Table 5.6 Estimated Empirical Distribution Parameters of Dust Lead Loadings by Surface Types

	Floors	Window Sills	Window Troughs
	mg/ft^2	mg/ft^2	mg/ft^2
Arithmetic Mean	14.0	194.0	1,990.9
Arithmetic Standard Deviation	481.8	1677.7	12,064.0
Geometric Mean	0.5	6.8	90.1
Geometric Standard Deviation[1]	9.6	16.5	14.4
25th Percentile	0.1	2.0	18.0
Median	0.9	8.4	89.4
75th Percentile	2.0	37.5	460.8
90th Percentile	6.9	175.3	2,824.2
95th Percentile	14.0	524.9	6,986.7
Number of Samples	3,925	2,316	1,614

[1] The geometric standard deviation is computed as exp(s), where s is the arithmetic standard deviation of the natural logarithms of the loadings (see, e.g., Gilbert, R. O. (1987) *Statistical Methods for Environmental Pollution Monitoring*, Van Nostrand Reinhold Company New York).

5.3 Association between Dust Lead Hazards and LBP Condition

Table 5.7 presents the prevalence of dust lead hazards in relation to the condition of the interior LBP. Dust lead hazards are more likely to exist in homes with deteriorated LBP. An estimated 61 percent of homes with significantly deteriorated LBP have lead dust hazards, while only 33 percent of homes with LBP in good condition have lead dust hazards. Only six percent of homes with no interior LBP have lead dust hazards. Although it appears from the data that the presence of LBP, especially significantly deteriorated LBP, contributes to higher dust lead hazard, there are additional sources of lead in the environment to account for dust lead in homes with no lead-based paint.

Table 5.7 allows one to compare the relative risks (with 95 percent confidence intervals on that risk) of interior lead dust hazards associated with different paint conditions. The presence of significantly deteriorated LBP makes a house 1.8 ($\pm$0.5) times as likely to have an interior lead dust hazard compared to a house where the LBP is in good condition, and 10.0 ($\pm$1.9) times as likely as a house

without LBP. Even a house with LBP in good condition is 5.4 (±0.8) times as likely to have interior lead dust hazards as one without any LBP.

Figure 5.1 Box Plots for Dust Lead Loadings by Room

Figure 5.2 Box Plots for Dust Lead Loadings by Surface

Table 5.7 Association Between Dust Lead Hazards and Presence and Condition of Interior Lead-based Paint

All HU Ages							
		No Interior LBP		Interior LBP in Good Condition		Significantly Deteriorated Interior LBP	
No Interior Dust Lead Hazards	Estimate[1]	62,752	66%	15,244	16%	2,389	2%
	Lower 95% CI[2]	60,141	63%	12,633	13%	1,565	1%
	Upper 95% CI	65,363	68%	17,855	19%	3,213	3%
Interior Dust Lead Hazards	Estimate	4,068	4%	7,508	8%	3,727	4%
	Lower 95% CI	2,584	3%	6,024	6%	2,505	3%
	Upper 95% CI	5,552	6%	8,992	9%	4,949	5%
Total HUs	95,688						

[1] Estimate is either the number of permanently occupied, noninstitutional housing units (000) in which children are permitted to live, or the percentage of total housing units (95,688).

[2] CI = 95% confidence interval for the estimated number or percent.

6. RESIDENTIAL SOIL LEAD

Chapter 6 presents estimates of the prevalence of soil lead by lead concentration, and the association between soil lead concentration and exterior lead-based paint condition. Relevant estimates are compared with the findings of the 1990 LBP Survey. The prevalence of soil lead hazards in housing is presented in Chapter 3. Since soil lead hazards include lead in soil in children's play areas, the estimates in this Chapter are based on the subsample of 375 homes with data on the presence or absence of children's play areas in the yards and on the extent of soil lead hazards in children's play areas.

6.1 Prevalence of Residential Soil Lead, All Sampled Locations

A composite soil sample was collected at each of five sites on the property of each dwelling unit: 1) near the most commonly used entrance, 2) the dripline and 3) the mid-yard line of the wall with the main entrance, and 4) the dripline and 5) mid-yard line of a second, randomly-selected wall. The main entrance sample was a composite sample of two cores from the main entrance area. The dripline and mid-yard samples on each wall were composite samples from three locations along the length of the sample site. In addition soil samples were collected from children's play areas for a subsample of homes. At each of these homes, up to four samples were collected from children's play equipment, when present; otherwise, one sample was collected from an area of the yard identified as being where children play. *The tables in this section and Section 6.2 are based on the maximum lead concentration among all of these soil samples*. Section 6.3 then presents data on soil lead concentrations in children's play areas, while Section 6.4 presents corresponding data for the "rest of the yard", i.e., areas not identified as children's play areas.

Table 6.1 presents the number and percentage of HUs by selected soil lead concentration thresholds: LOD, 50, 200, 400, 1,200, 1,600, 2,000, and 5,000 ppm. Table 6.1 includes all soil, whether bare or covered, and all sampled locations, both play areas and all other locations. An estimated 19 percent (±4%) of homes have soil lead levels below the limit of detection.[36] An estimated 76 percent (±4%[37]) of homes have soil lead levels below 400 ppm, 86% (±3%) have soil lead levels below 1,200 ppm, and 90 percent (±3%) of homes have soil lead levels below 2,000 ppm. Only 7 percent of homes were found to have soil lead above 2,000 ppm. The maximum soil values for each HU have been used in Table 6.1. The

[36] The sample limit of detection for this study was determined to be 20 ppm by testing four distinct soil types from among the study samples in accordance with EPA SW 840 Method 3050 procedures.

[37] All confidence intervals are at the 95 percent level for the estimated number or percentage.

effect of using the average soil lead for each HU would drive the distribution towards the lower thresholds, i.e. more homes have lower average soil lead concentrations.

Table 6.1 Distribution of Maximum Soil Sample (Bare and Covered) Lead Concentrations, All Sampled Locations

	Number of HUs (000)[1]			Percent of HUs (%)[2]			
Soil Lead	Estimate	Lower 95% CI[3]	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	HUs in Sample
LT[4] 20 ppm	18,489	12,592	24,386	19%	13%	25%	45
LT 50 ppm	36,844	30,336	43,352	39%	32%	45%	115
LT 200 ppm	63,876	61,834	65,919	67%	65%	69%	220
LT 400 ppm	72,720	69,108	76,333	76%	72%	80%	267
LT 1,200 ppm	81,966	78,717	85,215	86%	82%	89%	312
LT 1,600 ppm	85,685	83,204	88,166	90%	87%	92%	329
LT 2,000 ppm	86,301	83,687	88,916	90%	87%	93%	335
LT 5,000 ppm	90,123	87,951	92,295	94%	92%	96%	348
GE 5,000 ppm	2,987	1,554	4,420	3%	2%	5%	17
Missing[5]	335	0	957	0%	0%	1%	2
No soil	2,242	339	4,145	3%	0%	4%	8
Total	95,688						375

[1] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[2] All percentages are calculated with total housing units (95,688) as the denominator.

[3] CI = 95% confidence interval for the estimated number or percent.

[4] LT equals "less than." GE equals "greater than or equal to."

[5] Missing means that soil was present, but that no lead value is available (usually due to inaccessibility or respondent refusal). "No soil" means that there was no soil on the property to sample.

Care is to be exercised in comparing the tables in this Chapter with Tables 3.3 and 3.6, which tabulate the prevalence of soil lead hazards. The tables in this chapter present the distribution of residential soil lead concentrations at selected locations, while soil lead hazards are defined in terms of soil lead concentrations in two types of locations. Specifically, a housing unit is defined to have a soil lead hazard if soil lead concentrations exceed 400 ppm in play areas or exceed 2,000 ppm in the rest of the yard. Thus, the tables in this section do not directly compare with Tables 3.3 and 3.6.

Table 6.2 presents the number and percentage of HUs by selected soil lead concentration thresholds for bare soil only, but still for all sampled locations. Three percent of homes were found to have bare soil lead above the HUD Lead Safe Rule soil lead hazard of 2,000 ppm, while six percent are above the EPA Section 403 rule threshold of 1,200 ppm.

Table 6.2 Distribution of Maximum Soil Sample (Bare Soil Only) Lead Concentrations, All Sampled Locations

Bare Soil Lead	Number of HUs (000)[1]			Percent of HUs (%)[2]		
	Estimate	Lower 95% CI[3]	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI
LT 20 ppm[4]	22,774	17,987	27,561	24%	19%	29%
LT 50 ppm	37,866	32,190	43,541	40%	34%	46%
LT 200 ppm	62,590	57,343	67,836	65%	60%	71%
LT 400 ppm	67,893	61,644	74,141	71%	64%	77%
LT 1,200 ppm	71,617	65,317	77,917	75%	68%	81%
LT 1,600 ppm	73,988	67,283	80,693	77%	70%	84%
LT 2,000 ppm	74,765	67,846	81,683	78%	71%	85%
LT 5,000 ppm	76,308	70,537	82,079	80%	74%	86%
GE 5000 ppm	1,580	0	3,301	1%	0%	3%
No Bare Soil	15,413	9,815	21,011	16%	10%	22%
No Soil	2,242	339	4,145	2%	0%	4%
Missing	145	0	525	0	0%	1%

[1] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[2] All percentages are calculated with total housing units (95,688) as the denominator.

[3] CI = 95% confidence interval for the estimated number or percent.

[4] LT equals "less than." GE equals "greater than or equal to."

[5] Missing means that soil was present, but that no lead value is available (either the sample was not collected, e.g. due to inaccessibility or respondent refusal, or the laboratory did not submit a value). "No soil" means that there was no soil on the property to sample.

Table 6.3 presents the number and percentage of housing units by construction year for selected soil lead concentration thresholds for all soil, whether bare or covered, and for all sampled locations. In general, as the soil lead threshold increases, the number of homes meeting the criteria decreases as the housing unit age increases. In fact, only 0.4 percent of newer homes (1960-1998) have soil lead above 400 ppm, while this is the case for 66 percent of pre-1940 homes. Thus, the data suggest that older homes have higher soil lead concentrations than new homes.

Table 6.3 Distribution of Maximum Soil Sample (Bare and Covered) Lead Concentrations by Construction Year, All Sampled Locations

Soil Lead Concentration	Number of HUs (000)[1]				Percent of HUs (%)[2]			
	Before 1940	1940 - 1959	1960 - 1977	1978 - 1998	Before 1940	1940 - 1959	1960 - 1977	1978 - 1998
LT[3] 20 ppm	0	1,935	13,516	20,885	0%	9%	48%	70%
LT 50 ppm	508	9,655	23,113	28,094	3%	47%	83%	94%
LT 200 ppm	3,015	13,322	25,197	29,485	17%	65%	90%	99%
LT 400 ppm	4,715	15,683	26,921	29,569	27%	76%	97%	99%
LT 1,200 ppm	9,792	17,321	26,921	29,569	56%	84%	97%	99%
LT 1,600 ppm	11,873	17,411	26,921	29,569	68%	85%	97%	99%
LT 2,000 ppm	12,399	18,741	26,921	29,569	71%	91%	97%	99%
LT 5,000 ppm	14,437	19,605	26,921	29,569	82%	95%	97%	99%
GE 5,000 ppm	1,891	865	231	0	11%	4%	1%	0%
Missing[4]	145	0	190	0	1%	0%	1%	0%
No soil	1,003	939	95	205	6%	5%	0%	1%
Total	17,476	20,544	27,893	29,774	100%	100%	100%	100%

[1] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[2] All percentages are calculated with total housing units of that age as the common denominator.

[3] LT equals "less than." GE equals "greater than or equal to."

[4] Missing means that soil was present, but that no lead value is available (usually due to inaccessibility or respondent refusal). "No soil" means that there was no soil on the property to sample.

Table 6.4 presents the number and percentage of housing units by construction year for selected soil lead concentration thresholds for bare soil only, for all sampling locations. As seen above for all soil, as the soil lead threshold increases, the number of newer homes meeting the criteria for bare soil decreases faster than the older homes. In fact, practically no newer homes (1960-1998) have lead in bare soil above 1,200 ppm, and less than 4 percent have soil lead above 400 ppm.[38] Thus, the data suggest that older homes have higher bare soil lead levels than new homes. Since the amount of lead added to commercial residential paint declined from 1940 to 1980, these observations are not unreasonable, and have been reported by others.[39] However, no apparent trend in soil lead level was seen between different urbanization categories and soil lead concentration.

[38] Even fewer homes will have greater than 9 square feet of bare soil above 400 ppm or 2,000 ppm (soil lead hazard as specified in the Lead Safe Housing Rule).

[39] Francek, M. (1992.) *Soil lead levels in a small town environment: A case study from Mt. Pleasant, Michigan.* Environmental Pollution 76. pp. 251-257.

Table 6.4 Distribution of Maximum Soil Sample (Bare Soil Only) Lead Concentration by Construction Year, All Sampled Locations

Bare Soil Lead Concentration	Number of HUs (000)[1]				Percent of HUs (%)[2]			
	Before 1940	1940 - 1959	1960 - 1977	1978 – 1998	Before 1940	1940 - 1959	1960 - 1977	1978 - 1998
LT[3] 20 ppm	0	1439	5840	15495	0%	7%	21%	52%
LT 50 ppm	822	4,054	12,748	20,242	5%	20%	46%	68%
LT 200 ppm	4,772	10,770	21,392	25,655	27%	52%	77%	86%
LT 400 ppm	6,867	13,107	22,074	25,845	39%	64%	79%	87%
LT 1,200 ppm	8,629	13,958	23,185	25,845	49%	68%	83%	87%
LT 1,600 ppm	10,009	14,949	23,185	25,845	57%	73%	83%	87%
LT 2,000 ppm	10,695	15,039	23,185	25,845	61%	73%	83%	87%
LT 5,000 ppm	10,909	16,369	23,185	25,845	62%	80%	83%	87%
GE 5,000 ppm	1,106	475	0	0	6%	2%	0%	0%
Missing[4]	145	0	0	0	1%	0%	0%	0%
No Bare Soil	4,313	2,762	4,613	3,724	25%	13%	17%	13%
No Soil	1,003	939	95	205	6%	5%	0%	1%
Total	17,476	20,544	27,893	29,774	100%	100%	100%	100%

[1] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[2] All percentages are calculated with total housing units of that age as the common denominator.

[3] LT equals "less than." GE equals "greater than or equal to."

[4] Missing means that soil was present, but that no lead value is available (usually due to inaccessibility or respondent refusal). "No soil" means that there was no soil on the property to sample.

Figure 6.1 presents a series of boxplots showing the distribution of soil lead concentrations at each of the five sample sites. As with paint lead and dust lead loadings, soil lead concentrations are extremely skewed with over three-fourths of the samples under 200 ppm, but some samples are well above 1,000 ppm.

Table 6.5 presents selected parameters of the distributions of soil lead concentrations by sample sites, corresponding to the boxplots in Figure 6.1. Table 6.5 also presents geometric means and standard deviations. As with the distributions of paint lead loadings and dust lead loadings, the distribution of soil lead concentrations is right-skewed. Thus, a normal distribution would not be a suitable model for the distribution. A lognormal distribution would be a more suitable distribution. Chapter 7 includes a discussion of modeling these data.

Figure 6.1 Box Plots for Lead in Soil Samples by Sample Site

Table 6.5 Estimated Empirical Distribution Parameters of Soil Lead Concentrations by Sample Site

	Main Entry	Wall 1 Dripline	Wall 2 Dripline	Wall 1 Midyard	Wall 2 Midyard
	ppm	ppm	ppm	Ppm	ppm
Arithmetic Mean	234.3	242.4	403.5	86.6	122.7
Arithmetic Standard Deviation	1,094.5	817.7	1,612.9	195.0	360.7
Geometric Mean	29.3	29.2	31.1	15.5	16.9
Geometric Standard Deviation[1]	11.6	12.4	14.9	11.9	12.5
25th Percentile	12.1	11.4	10.8	7.8	8.5
Median	40.2	38.8	40.3	27.0	29.1
75th Percentile	133.4	130.7	165.4	76.3	74.2
90th Percentile	433.5	553.5	712.5	209.0	277.0
95th Percentile	1,005.8	1,110.8	1,444.5	411.3	538.8
Number of Samples	707	704	704	723	728

[1] The geometric standard deviation is computed as exp(s), where s is the arithmetic standard deviation of the natural logarithms of the concentrations (see, e.g., Gilbert, R. O. (1987) *Statistical Methods for Environmental Pollution Monitoring* , Van Nostrand Reinhold Company New York).

6.2 Association between Bare Soil Lead and Exterior Paint Condition

Table 6.6 shows the association between bare soil lead concentration and the condition of the exterior LBP. Higher bare soil lead concentrations occur for homes with deteriorated LBP. An estimated 27 percent of homes with intact or minimally-deteriorated LBP have bare soil lead below 20 ppm, while only 1 percent of homes with deteriorated LBP have bare soil levels below 20 ppm. Only 5 and 2 percent of homes with intact LBP have bare soil lead levels above 1,200 and 2,000 ppm, respectively, while 23 and 13 percent of homes with deteriorated LBP have bare soil lead levels above 1,200 and 2,000 ppm, respectively.

Table 6.6 Association Between Bare Soil Lead Concentration and Presence of Significantly Deteriorated Exterior LBP, All Sampled Locations

Bare Soil Lead	Housing Units without Significantly Deteriorated Exterior LBP[1,2]			Housing Units with Significantly Deteriorated Exterior LBP[1,2]		
	Percent	Lower 95% CI[3]	Upper 95% CI	Percent	Lower 95% CI	Upper 95% CI
LT 20 ppm[4]	27%	21%	33%	1%	0%	2%
LT 50 ppm	44%	37%	51%	7%	0%	13%
LT 200 ppm	70%	64%	75%	35%	11%	58%
LT 400 ppm	75%	69%	81%	43%	20%	67%
LT 1,200 ppm	78%	72%	84%	50%	28%	71%
LT 1,600 ppm	80%	74%	86%	56%	36%	77%
LT 2,000 ppm	81%	74%	87%	60%	39%	81%
LT 5,000 ppm	82%	77%	87%	65%	45%	86%
GE 5,000 ppm	1%	0%	2%	8%	0%	17%
Missing[5]	0%	0%	0%	1%	0%	4%
No Bare Soil	15%	11%	20%	22%	3%	41%
No Soil	2%	0%	4%	4%	0%	9%

[1] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[2] Percentages are calculated with the number of HUs with and without deteriorated LBP, 11,473 and 84,215, respectively, as the denominators.

[3] CI = 95% confidence interval for the estimated number or percent.

[4] LT equals "less than." GE equals "greater than or equal to."

[5] Missing means that soil was present, but that no lead value is available (usually due to inaccessibility or respondent refusal). "No soil" means that there was no soil on the property to sample.

6.3 Prevalence of Bare Soil Lead in Children's Play Areas

Table 6.7 presents the number and percentage of housing units with bare soil lead in children's play areas above selected concentration thresholds: LOD, 50, 200, 400, 1,200, 1,600, 2,000, and 5,000 ppm. An estimated 29 percent (±6%) of homes have bare soil lead levels in play areas below the limit of detection.[40] An estimated 95 percent (±8%) of homes with play areas have soil lead levels below 400 ppm, that is only 5 percent of homes were found to have bare soil lead equal to or above the HUD Lead Safe Housing Rule soil lead hazard of 400 ppm for children's play areas. An estimated 1 percent (±2%) of homes have play area soil lead levels above 2,000 ppm.

[40] The sample limit of detection for this study was determined to be 20 ppm by testing four distinct soil types from among the study samples in accordance with EPA Method 3050 procedures.

Where there were more than one soil sample collected from children's play areas at a home, the maximum soil value for housing unit has been used in Table 2.1. The effect of using the average soil lead for each housing unit would drive the distribution towards the lower thresholds, i.e. more homes would have lower soil lead concentrations.

Table 6.7 Distribution of Maximum Soil Lead Concentrations in Children's Play Areas

Bare Play Area Soil Lead	Number of HUs (000)[1]			Percent of HUs (%)[2]			HUs in Sample
	Estimate	Lower 95% CI[3]	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
LT[4] 20 ppm	27,385	22,738	32,033	29%	24%	33%	81
LT 50 ppm	47,526	40,653	54,398	50%	42%	57%	166
LT 200 ppm	65,555	58,100	73,010	69%	61%	76%	248
LT 400 ppm	71,548	63,830	79,267	75%	67%	83%	274
LT 1,200 ppm	73,911	66,807	81,014	77%	70%	85%	291
LT 1,600 ppm	74,327	67,281	81,372	78%	70%	85%	293
LT 2,000 ppm	74,627	67,616	81,638	78%	71%	85%	295
LT 5,000 ppm	76,025	69,435	82,614	79%	73%	86%	298
GE 5,000 ppm	380	0	1,227	0%	0%	1%	1
No play area	12,368	6,686	18,050	13%	7%	19%	53
Missing[5]	6,916	1,885	11,946	7%	2%	12%	23
Total	95,688			100%			375

[1] "Housing units" are permanently occupied, noninstitutional residential units in which children are permitted to live.
[2] All percentages are calculated with total housing units (95,688) as the denominator.
[3] CI = 95% confidence interval for the estimated number or percent.
[4] LT equals "less than." GE equals "greater than or equal to."
[5] Missing means that soil was present, but that no lead value is available (usually due to inaccessibility or respondent refusal). "No soil" means that there was no soil on the property to sample.

Table 6.8 presents the number and percentage of housing units with bare soil lead concentration in children's play areas by selected thresholds, by housing unit construction year. In general, as the soil lead threshold increases, the number of homes meeting the criteria decreases as the housing unit age increases. In fact, nearly all newer homes (1960-1998) have bare play area soil lead below 400 ppm. Thus, the data suggest that older homes have higher bare play area soil lead concentrations than new homes. Since the amount of lead added to commercial residential paint declined from 1940 to 1980, these observations are not unreasonable, and have been reported by others.[41]

[41] Francek, M. (1992.) *Soil lead levels in a small town environment: A case study from Mt. Pleasant, Michigan.* Environmental Pollution 76. pp. 251-257.

Table 6.8 Distribution of Maximum Soil Lead Concentrations in Children's Play Areas, by Construction Year

	Number of HUs (000)[1]				Percent of HUs (%)[2]			
Bare Soil Lead Concentration	**Before 1940**	**1940 - 1959**	**1960 – 1977**	**1978 – 1998**	**Before 1940**	**1940 – 1959**	**1960 - 1977**	**1978 – 1998**
LT[4]20 ppm	88	2,879	9,298	15,120	1%	14%	33%	51%
LT 50 ppm	2,079	7,033	17,803	20,611	12%	34%	64%	69%
LT 200 ppm	8,133	13,149	22,216	22,057	65%	71%	81%	78%
LT 400 ppm	11,315	14,484	22,474	23,275	47%	64%	80%	74%
LT 1,200 ppm	13,142	14,958	22,536	23,275	75%	73%	81%	78%
LT 1,600 ppm	13,558	14,958	22,536	23,275	78%	73%	81%	78%
LT 2,000 ppm	13,768	15,048	22,536	23,275	79%	73%	81%	78%
LT 5,000 ppm	14,261	15,953	22,536	23,275	82%	78%	81%	78%
GE 5,000 ppm	380	0	0	0	2%	0%	0%	0%
No Play Area	2,222	4,489	1,947	3,710	13%	22%	7%	12%
Missing[5]	613	102	3,410	2,790	4%	0%	12%	9%
Total	17,476	20,544	27,893	29,774	100%	100%	100%	100%

[1] "Housing units" are permanently occupied, noninstitutional housing units in which children are permitted to live.
[2] All percentages are calculated with total housing units of that age as the common denominator.
[3] LT equals "less than." GE equals "greater than or equal to."
[4] Missing means that soil was present, but that no lead value is available (usually due to inaccessibility or respondent refusal). "No bare soil" means that there was no bare soil in children's play areas on the property to sample.

Table 6.9 shows the association between bare play area soil lead concentration and the condition of the exterior LBP. Higher bare soil lead concentrations occur in play areas for homes with significantly deteriorated LBP. An estimated 32 percent (±5%) of homes with intact or minimally-deteriorated LBP have bare play area soil lead below 20 ppm, while only one percent (±2%) of homes with significantly deteriorated LBP have bare soil levels below 20 ppm. Only eight percent of homes with intact or minimally-deteriorated LBP have bare play area soil lead levels above 400 ppm, while 35 percent of homes with significantly deteriorated LBP have bare soil lead levels above 400 ppm.

Table 6.9 Association Between Bare Soil Lead Concentration and Presence of Signficantly Deteriorated Exterior LBP, in Children's Play Areas

	Housing Units without Significantly Deteriorated Exterior LBP (%)[1,2]			Housing Units with Significantly Deteriorated Exterior LBP (%)[1,2]		
Bare Play Area Soil Lead	**Estimate**	**Lower 95% CI[3]**	**Upper 95% CI**	**Estimate**	**Lower 95% CI**	**Upper 95% CI**
LT 20 ppm[4]	32%	26%	38%	1%	0%	3%
LT 50 ppm	54%	46%	62%	17%	4%	31%
LT 200 ppm	75%	67%	83%	72%	58%	86%
LT 400 ppm	70%	62%	78%	55%	37%	73%
LT 1200 ppm	77%	70%	85%	77%	64%	90%
LT 1600 ppm	78%	70%	85%	79%	66%	92%
LT 2,000 ppm	78%	70%	85%	80%	66%	93%
LT 5,000 ppm	78%	71%	86%	87%	74%	99%
GE 5,000 ppm	0%	0%	0%	3%	0%	10%
No Play Areas	14%	7%	20%	7%	0%	17%
Missing[5]	8%	2%	14%	3%	0%	7%

[1] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[2] Percentages are calculated with the number of HUs with and without deteriorated LBP, 10,651 and 85,037, respectively, as the denominators.

[3] CI = 95% confidence interval for the estimated number or percent.

[4] LT equals "less than." GE equals "greater than or equal to."

[5] Missing means that soil was present, but that no lead value is available (usually due to inaccessibility or respondent refusal). "No soil" means that there was no soil on the property to sample.

6.4 Prevalence of Bare Soil Lead in the Rest of the Yard

Table 6.10 presents the number and percentage of housing units with bare soil lead in the rest of the yard -- i.e., areas *not* identified as children's play areas -- above selected concentration thresholds: LOD, 50, 200, 400, 1,200, 1,600, 2,000, and 5,000 ppm. An estimated 20 percent (±6%) of homes have bare soil lead levels in the rest of the yard below the limit of detection.[42] An estimated 84 percent (±4%) of homes have soil lead levels below 1,200 ppm in the rest of the yard, while an estimated 6 percent (±2%) of homes have soil lead levels above 2,000 ppm.

[42] The sample limit of detection for this study was determined to be 20 ppm by testing four distinct soil types from among the study samples in accordance with EPA Method 3050 procedures.

Table 6.10 Distribution of Maximum Bare Soil Lead Concentrations in the Rest of the Yard

Soil Lead Concentration	Number of HUs (000)[1]			Percent of HUs (%)[2]			HUs in Sample
	Estimate	Lower 95% CI[3]	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
LT[4] 20 ppm	18,812	13,240	24,384	20%	13%	25%	52
LT 50 ppm	36,098	30,040	42,157	38%	31%	44%	117
LT 200 ppm	62,996	59,433	66,558	66%	62%	70%	213
LT 400 ppm	70,639	66,354	74,923	74%	69%	78%	259
LT 1,200 ppm	80,409	76,692	84,126	84%	80%	88%	305
LT 1,600 ppm	84,128	80,907	87,348	88%	85%	91%	322
LT 2,000 ppm	84,444	81,224	87,663	88%	85%	92%	326
LT 5,000 ppm	87,361	84,167	90,555	91%	88%	95%	337
GE 5,000 ppm	2,987	1,554	4,420	3%	2%	5%	17
No Soil/No Bare Soil[5]	2,310	375	4,245	2%	0%	4%	9
Missing[5]	3,029	704	5,354	3%	1%	6%	12
Total	95,688			100%			375

[1] "Housing units" are permanently occupied, noninstitutional residential units in which children are permitted to live.
[2] All percentages are calculated with total housing units (95,688) as the denominator.
[3] CI = 95% confidence interval for the estimated number or percent.
[4] LT equals "less than." GE equals "greater than or equal to."
[5] Missing means that soil was present, but that no lead value is available (usually due to inaccessibility or respondent refusal). "No soil" means that there was no soil in the rest of the yard to sample. "No bare soil" means there was no bare soil in the rest of the yard.

Table 6.11 presents the number and percentage of housing units with bare soil lead concentration in the rest of the yard by selected thresholds, and by housing unit construction year. In general, as the soil lead threshold increases, the number of homes meeting the criteria decreases as the housing unit age increases. In fact, nearly all newer homes (1960-1998) have bare soil lead concentrations below 400 ppm in the rest of the yard.

Table 6.11 Distribution of Maximum Bare Soil Lead Concentrations in the Rest of the Yard, by Construction Year

	Number of HUs (000)[1]				Percent of HUs (%)[2]			
Bare Soil Lead Concentration	**Before 1940**	**1940 - 1959**	**1960 – 1977**	**1978 – 1998**	**Before 1940**	**1940 – 1959**	**1960 - 1977**	**1978 – 1998**
LT[4]20 ppm	0	425	2,800	15,587	0%	2%	10%	52%
LT 50 ppm	508	1,880	13,441	20,268	3%	9%	48%	68%
LT 200 ppm	2,807	9,848	22,521	27,820	16%	48%	81%	93%
LT 400 ppm	4,602	13,412	24,540	28,084	26%	65%	88%	94%
LT 1,200 ppm	9,531	16,446	26,264	28,168	54%	80%	94%	94%
LT 1,600 ppm	11,613	18,083	26,264	28,168	65%	88%	94%	94%
LT 2,000 ppm	11,929	18,083	26,264	28,168	67%	88%	94%	94%
LT 5,000 ppm	13,967	18,507	26,719	28,168	80%	90%	96%	94%
GE 5,000 ppm	1,891	865	231	0	11%	4%	1%	0%
No Soil/No Bare Soil[5]	1,211	939	160	0	7%	5%	1%	0%
Missing[5]	407	233	783	1,606	2%	1%	3%	5%
Total	17,476	20,544	27,893	29,774	100%	100%	100%	100%

[1] "Housing units" are permanently occupied, noninstitutional housing units in which children are permitted to live.
[2] All percentages are calculated with total housing units of that age as the common denominator.
[3] LT equals "less than." GE equals "greater than or equal to."
[4] Missing means that soil was present, but that no lead value is available (usually due to inaccessibility or respondent refusal).
[5] "No soil" means that there was no soil in the rest of the yard to sample. "No bare soil" means there was no bare soil in the rest of the yard.

6.5 Comparison of Prevalence of Soil Lead to the 1990 LBP Survey

Table 6.12 compares the prevalence of soil lead found in the National Survey with the prevalence of soil lead found in the 1990 LBP Survey. The estimate of homes reported for the National Survey have been limited to those with 500 ppm soil lead or greater and to homes built before 1980 for comparability to the 1990 LBP Survey protocols and findings (see Appendix A for a comparison of the protocols for the two studies). Statistical comparison shows no significant difference in the prevalence of soil above or below 500 ppm in the two studies.

Table 6.12 Comparison of the Prevalence of Lead-Contaminated Bare Soil in the National Survey and the 1990 LBP Survey

	1990 LBP Survey (pre-1980 HUs)		Current National Survey (pre-1980 HUs)	
	Number (000)	**Percent (%)**	**Number (000)**	**Percent and (CI) [1] (%)**
HUs with Bare Soil Lead Above 500 ppm	15,699	20%	15,909	23% (19-27%)
HUs with Bare Soil Lead Equal to or Below 500 ppm	61,478	80%	50,290	73% (70-77%)
No Bare Soil	--	--	2,557	4%
Total	77,177	100%	68,756	100%

[1] CI = 95% confidence interval for the estimated percent.

7. SOURCES OF ERROR IN THE NATIONAL SURVEY DATA

Chapter 7 examines the quality of the data and the resulting quality of projected national estimates. The greatest source of error in the National Survey estimates is sampling error – as discussed in Volume II, Chapter 2. This chapter addresses two additional important sources of error – nonresponse bias and measurement bias – and discusses their effects on the national estimates of the prevalence of LBP, lead in dust, and lead in soil.

Another source of error in the survey is response bias, i.e., how correct was the information provided by the respondents? Significant information obtained from respondents included year of construction (HU age) and age of children. These data were not verified by other means and are thus associated with an unknown amount of error. However, the overall distribution of HU age and age of children reported by survey respondents were consistent with study expectations (see Volume II, Chapter 2), indicating no systematic bias in these responses.

The chapter concludes with a summary of the data collection quality assurance activities, including results of telephone verification, field team audits, field dust wipe blanks, and laboratory performance on dust and soil quality control samples.

7.1 Statistical Concepts and Terminology

There are two broad types of error in survey estimates: sampling error and nonsampling error:

- **Sampling error:** Sampling error arises from surveying a random sample rather than a complete census of all housing units (HUs). It is a function of the sample size and sample design. Different samples of the same size drawn using the same sample design will yield varying estimates of the population parameters. This variation about the true population parameter is the sampling error. Sampling error is measured by the standard error (square root of the variance).

- **Nonsampling error:** Nonsampling errors arise from a number of sources, including differential response rates from different demographic groups, types of HUs, and geographical areas; unknown differences between the respondents and nonrespondents; differences between the sample frame and the target population; some types of processing and data reduction techniques; and classification bias due to measurement

error inherent in XRF and laboratory instrumentation and variation in a measured parameter across a surface and among rooms.

Throughout the report, the term *weight* has been used in conjunction with the sampled HUs, rooms, and surfaces. It is important that these terms be understood.

- **Housing Unit (HU) weight:** The HU weight is the number of HUs in the target population that a single unit represents. The weight can be calculated by taking the inverse of the probability of selection for that unit. Thus, if the probability of selection is 0.01, the sample weight is 100. With multi-stage samples, the overall probability of selection is the product of the conditional probabilities of selection at each stage. HU weights reflect nonresponse adjustments and post-stratification to the 1997 American Housing Survey (AHS) housing unit totals by Census region, HU age category, and presence of children under age 18.

- **Room weight:** The room weight is the number of rooms in the target population that a single room represents. Room weights were determined by dividing the post-stratified HU weights by the probability of room selection based on the room inventory of each HU. A nonresponse adjustment was then made to account for noncompleted rooms. A room was only considered to be complete if some environmental samples and data were collected in the room.

- **Component weight:** The component weight is the number of components in the target population that a single component represents. For most lead samples, the component weight equaled the nonresponse-adjusted room weight. There were two exceptions: 1) XRF measurements on windows and doors, and 2) window dust samples. For these components, a sample of one door or window per room was selected. To complete component weights for these components, the nonresponse-adjusted room weights were divided by the component probability of selection, i.e., the inverse of the total number of doors or windows in the room.

7.2 Potential for Nonresponse Bias

The objective of the nonresponse analysis was to estimate the potential impact of survey nonresponse on the estimated prevalence of lead-based paint (LBP) in housing. To accomplish this, three analyses were conducted. First, the weighted distribution of the National Survey sample was compared with the AHS and CPS (this analysis was presented in Chapter 2). Second, an analysis of completion rates was performed to look for correlates with nonresponse. Third, the survey estimates for the "hard-to-recruit" and initial refusal HUs were compared with estimates from HUs that were relatively easy to recruit and had no history of refusal. In this latter case, the hard-to-reach, but completed HUs and HUs that initially refused served as a proxy for the nonrespondents.

7.2.1 Analysis of Completion and Response Rates

An analysis of completion rates was conducted for the entire sample of 1,984 fielded HUs. The analysis looked at the relationship between completion rates and factors such as age of housing, race, ethnicity, geographic location, income, tenure, and presence of multi-family housing. Given that these data were generally not available at the individual HU level for the noncompletes, data for the block group to which the HU belonged was used for the entire sample, with the exception of HU age. The housing unit age reported by respondents was used when available, which was the case for approximately one-half of the HUs. The source of the block group data was the 1990 Census.

Completion rates were also compared for HUs receiving an advance letter addressed to "Current Resident" and HUs receiving a letter addressed to a household member. The household names were obtained from a database of white page directory listings that had been supplemented with subscription lists and other databases (and in some cases the Internet) for about 40 percent of the sample.

The completion rates for the analysis were calculated as the weighted proportion of the HUs sampled that completed both screener and data collection, or else were found to be ineligible. Ineligibles were considered to be screener completes in the sense that their eligibility status was determined during the screener. For a large proportion of the sample (39%), eligibility could not be determined, usually because contact could not be made. Most nonresponse occurred at the screener stage and resulted in unknown eligibility status. Of the 1,984 HUs sampled, 831 completed both the screener and data collection and 229 were found to be ineligible. Of the remaining 924 that did not complete the data collection, 149 were eligible and another 775 were of unknown eligibility. Thus, there were 1,060 completes and 924 noncompletes overall. The overall unweighted completion rate for the survey was 53.4 percent; the overall weighted completion rate was 53.1 percent.

Formulas for unweighted screener and data collection completion rates are given below, along with the eligibility rate, refusal rate, and overall response rate. The overall completion rate is calculated as the product of the completion rate at each stage.[36]

[36] In the data collection completion rate, the ineligible cases are included in both numerator and denominator. If the ineligible cases are not included, the data collection completion rate drops from 90 to 88 percent.

$$\text{Screener completion rate} = 100 \text{ x } \frac{\#\text{ screener completes} + \#\text{ ineligible}}{\#\text{ fielded}} = 100 \text{ x } \frac{943 + 229}{1{,}984} = 59\%$$

$$\text{Data collection completion rate} = 100 \text{ x } \frac{\#\text{ eligible completing data collection} + \#\text{ ineligible}}{\#\text{ eligible completing screener} + \#\text{ ineligible}} = 100 \text{ x } \frac{1{,}060}{1{,}172} = 90\%$$

The overall response rate measures the response among eligible HUs. The number of eligible nonrespondents must be estimated because eligibility cannot usually be established for households that don't complete the screener. It is assumed that the eligibility rate among HUs whose eligibility is unknown is the same as for HUs that did complete the screener. The eligibility rate among HUs that completed a screener was 81 percent. The refusal rate is the rate of refusal among HUs where contact was established. (Numerous attempts were made to gain cooperation. Among respondents, two-thirds cooperated on the first or second attempt. While the average number of attempts to complete was 2.6, some housing units didn't cooperate until the eleventh attempt.) HUs that were vacant or couldn't be located, that had no one at home, that were in a locked, gated community where access couldn't be gained, or that couldn't otherwise be contacted were subtracted from the total sample size of 1,984 in the denominator. The overall response rate for the survey was 51.7 percent.

$$\text{Eligibility Rate} = 100\% \text{ x } \frac{\#\text{ Eligible}}{\#\text{ Eligible} + \#\text{ Ineligible}} = 100\% \text{ x } \frac{943}{943 + 229} = 81\%$$

$$\text{Refusal Rate} = 100 \text{ x } \frac{\#\text{ of refusals}}{\#\text{ contacted}} = 100 \text{ x } \frac{564}{1{,}634} = 34.5\%$$

$$\text{Overall response rate} = 100 \text{ x } \frac{\#\text{ eligible completing data collection}}{\#\text{ eligible completing data collection} + \#\text{ eligible nonrespondents}}$$

$$= \frac{831}{831 + (149 + .81 * 775)} = 51.7\%$$

Overall completion rates by Census Division and block group characteristics such as race/ethnicity, housing age, and type of housing are presented in Table 7.1. Mean percents for several characteristics by completion status are given in Table 7.2. For housing age, the modal or predominant

building age category for the block group was assigned to the HU, except when HU age was available for survey respondents. It is important to keep in mind that (with the exception of HU age) the characteristics apply only to the block group in which the HU is located, and may not apply to the HU itself. The associations between completion status and these characteristics were tested using chi-square and t-tests that take into account the HU weights and the survey design. The p-values for chi-square tests of association are given in Table 7.1; p-values for the t-tests are given in Table 7.2.

Significant associations were found between completion status and percents Hispanic and African American, percent below the federal poverty level, housing age, and tenure (see Table 7.2). In Table 7.1, the highest response rates were found among HUs in block groups with 30 percent or more Hispanic population, 30 percent or more in poverty, and in newer housing (1978 or later). This means that a greater potential for nonresponse bias would exist had these characteristics not been used in adjusting for nonresponse at the screener and data collection stages. Nonresponse adjustment factors were calculated within cells defined by the block group percent of low-income population, percent of Hispanic or African American population, and percent of pre-1940 and pre-1960 housing. In addition, the nonresponse-adjusted HU weights were poststratified to 1997 AHS housing unit totals by Census region, housing unit age, and presence of a child under 18. Use of the final adjusted weights in all analyses should therefore greatly reduce this potential bias in making estimates for the national housing stock.

Table 7.1 National Survey Completion Rates by 1990 Census Block Group Characteristics

1990 Census Block Group Characteristic	Number of HUs	Unweighted Completion Rate	Weighted Completion Rate	P-Value for Chi-square test[1]
Census Division				
New England	102	52%	53%	0.42
Middle Atlantic	289	53%	49%	
East North Central	289	49%	46%	
West North Central	181	55%	55%	
South Atlantic	326	52%	53%	
East South Central	144	53%	54%	
West South Central	208	56%	58%	
Mountain	136	57%	58%	
Pacific	309	56%	57%	
% Hispanic Population				
Less than 30% Hispanic	1832	52%	52%	0.005
30% or more Hispanic	152	65%	65%	
% African American Population				
Less than 30% African American	1731	52%	53%	0.08
30% or more African American	253	60%	59%	
% Population in Poverty				
Less than 30% in Poverty	1796	53%	52%	0.04
30% or more in Poverty	188	60%	61%	
% Multi-family Housing Units (5+)				
Less than 30% Multi-family HUs	1522	53%	53%	0.42
30% or more Multi-family HUs	462	56%	55%	
Age of Housing Unit[2]				
Pre-1940	456	48%	45%	<0.001
1940 – 1959	363	59%	60%	
1960 – 1977	806	47%	45%	
1978 and later	359	70%	74%	

[1] Chi-square test for association between completion rate and housing characteristic. The test takes into account the HU weights and sample design.

[2] Reported HU age used when available for HUs completing screener.

The presence or absence of a household member name on the advance letter was also significantly correlated with completion rates. For HUs located in higher income block groups (i.e. fewer than 30 percent of the households are below the federal poverty level), the response rate for HUs with a name on the advance letter was significantly **lower** ($p = .01$) than for HUs receiving a letter addressed to "Current Resident" (48% vs. 56%). For HUs located in lower income block groups (i.e. more than 30 percent of the households are below the federal poverty level), however, the completion rates were not significantly different. While it may seem anomalous that HUs whose advance letter was addressed to

"Current Resident" should have higher response rates, the explanation likely lies with the probability that even within the higher income block groups, the HUs where a household name was available were more likely to have higher incomes due to those households' greater incidence on available lists such as motor vehicle and voter registration. Higher income HUs had lower response rates (see Tables 7.1 and 7.3) to this survey, presumably a function of the $200 incentive for participation having greater value for poor households.

Table 7.2 National Survey Mean Percents for Completed and Noncompleted Housing Units by 1990 Census Block Group Characteristics

1990 Census Block Group Characteristic	Mean of Characteristic: Completes	Mean of Characteristic: Noncompletes	P-value for t-test of significant difference between completes and noncompletes[1]
Percent HUs Pre-1940 [2]	18%	25%	0.001
Percent Population below Poverty Level	12%	11%	0.080
Percent Multi-Family HUs (5+)	17%	16%	0.535
Percent Multi-Family HUs (20+)	7%	7%	0.908
Percent HUs Owned	63%	66%	0.042
Percent Population: African American	11%	8%	0.006
Percent Population: Hispanic	8%	5%	0.005

[1] The test takes into account the HU weights and sample design.
[2] HU age reported by respondents was used when available for HUs completing screener.

Response rates for the play areas augmentation effort were also calculated using the above formula. The 28 vacant or demolished housing units were included in the denominator of the response rate calculations because they are considered to be part of the eligible housing unit population, though no soil lead measurements were obtained for them in the augmentation. Weighted and unweighted response rates were examined as in Table 7.1, but given the smaller sample size the characteristics were restricted to Census Region, building age category, and soil lead stratum (one stratum was of PSUs with 0-2 homes with soil lead at least 200 ppm in the original data collection; another, with 3-6 homes; and the third, with 7 or more homes; see Volume II, chapter 2, for details). The national response rate for the augmentation was 79.5 percent weighted and 78.0 percent unweighted. For each subset the response rate remained between 71 and 85 percent. None of the response rate differences observed for the play area data were statistically significant at the alpha = .10 level.

7.2.2 Comparison of "Hard-to-Recruit" Versus "Easy-to-Recruit" HUs

Lead measurements were not available for the HUs whose occupants refused to participate in the survey or who could not be contacted, so it is not possible to know how their participation would have changed the estimates of lead prevalence in housing. However, if the HUs that initially refused but later cooperated are similar to the survey nonrespondents, they may be considered as a proxy group for the nonrespondents. These HUs have lead measurements, which can be used to compare them with the initial respondents, i.e. those with no initial refusal history. If they are significantly different, this may indicate the likely direction of the nonresponse bias in the lead prevalence estimates. HUs requiring several attempts to complete the screener could also serve as a proxy for the nonrespondents, since this is where most of the nonresponse in the survey occurred.

The initial refusals were compared with HUs with a history of no refusal. HUs requiring 4 or more attempts to complete the screener were also compared with those requiring 3 or fewer attempts. The number of attempts was split at 3-4 for two reasons. Two-thirds of respondents cooperated on the first or second attempt and the average number of attempts to complete was 2.6. The comparisons were made for two key statistics and by the housing characteristics recorded by the interviewer. The statistics were 1) the presence of LBP anywhere in the home, 2) the presence of deteriorated LBP anywhere in the home, 3) presence of LBP hazard anywhere in the home, and 4) the presence of a soil lead hazard. The housing characteristics were the household respondent's race/ethnicity, household income, tenure, building age, and presence of a child under 18. Chi-square tests of association between whether or not the household had initially refused and these characteristics were performed. Similarly, the association between whether or not the household required more than three attempts to obtain a completed screener and each of the characteristics above was tested using chi-square tests. The results of these analyses are presented in Table 7.3. The chi-square statistics took into account the HU weights and the National Survey sample design.

Table 7.3 shows that poorer households were much less likely to have an initial refusal, and required fewer attempts to obtain a completed screener. This is consistent with earlier analysis showing higher response rates for lower income households. It could be that the monetary incentive was more effective among lower income households in improving response rates, or that higher income HUs were more difficult to contact.

Table 7.3 also shows that households with LBP, significantly deteriorated LBP, significant LBP hazard, or soil lead hazard were just as likely to require more than three attempts to complete the screener as those without these lead characteristics. While households with LBP or soil hazards were just as likely to initially refuse as other households, those with significantly deteriorated LBP or LBP hazards were significantly more likely to initially refuse than those without these characteristics. This could be due to the fact that more lower income homes participated in the survey and lower income homes are more likely to have these characteristics.

Table 7.3 Comparison of Easy-to-Recruit Respondents Versus Hard-to-Recruit Respondents by Reported Housing Characteristics

National Survey Estimates	Initial Refusal (%)	p-value[1]	More than 3 Attempts to Complete Screener (%)	p-value[1]
Presence of LBP anywhere in HU				
Yes	9.2	0.60	17.3	0.67
No	10.0		15.1	
Presence of Significantly Deteriorated LBP anywhere				
Yes	6.0	0.05	12.8	0.29
No	10.4		16.7	
Presence of Significant LBP Hazard in HU				
Yes	5.6	0.0007	15.8	0.84
No	11.6		16.5	
Presence of Soil-Lead Hazard				
Yes	8.7	0.85	6.2	0.29
No	9.9		16.7	
Ethnicity				
Hispanic	10.7	0.78	9.6	0.14
Non-Hispanic	9.7		16.8	
Race				
White	10.2	0.38	16.9	0.12
African American	6.7		11.7	
Asian, Pacific Islander, Hawaiian, American Indian, Other	8.9		14.4	
Presence of Child under 18				
Yes	9.9	0.85	15.1	0.31
No	9.5		16.6	
Year of Construction				
Pre-1940	7.2	0.22	18.6	0.18
1940 – 1959	6.1		11.5	
1960 – 1977	12.1		13.3	
1978 or later	11.4		20.2	
Tenure (moved up to be w/hsg info)				
Owned	11.2	0.03	15.8	0.15
Rented	6.3		16.8	
Type of Housing				
Single-family	10.3	0.02	15.4	0.58
Multi-family	5.8		19.9	
Household Income				
Less than $30,000	4.7	<0.0001	12.3	0.03
$30,000 or More	11.7		17.8	
Household Income				
Less than $20,000	4.7	0.05	11.1	0.02
$20,000 - $39,999	6.8		15.6	
$40,000 - $59,999	10.9		16.8	
$60,000 and over	13.5		18.9	
Poverty				
Below Poverty Level	4.6	0.003	9.9	0.005
At or Above Poverty Level	9.8		17.0	

[1] Chi-square test of association between Ease of Recruitment and Reported Housing Characteristics.

The nonresponse analysis shows that the households that responded were more likely to be located in densely Hispanic and low income areas, and to be renters as opposed to home owners. They are also more likely to live in newer housing (post-1977).

If the initial refusals who agreed to cooperate are representative of nonrespondents, there would be a potential for bias in unweighted estimated prevalence of HUs with deteriorated LBP or LBP hazards. This means that there would be a potential for bias in the estimated prevalence of HUs with an LBP hazard. However, this was partially corrected by using race/ethnicity, low-income indicators, and building age in making nonresponse adjustments to the HU weights. The weighting adjustments do not eliminate nonresponse bias completely, but they do reduce it when variables that are correlated with both the response rates and propensity to have a lead hazard are used in the nonresponse adjustments. Comparison of the nonresponse-adjusted and poststratified weighted distribution of housing from the National Survey with the AHS and CPS in Table 2.1 show that the weighted National Survey sample matches the national housing distribution closely. These results suggest that there is probably not a serious nonresponse bias in the weighted estimates of lead hazard prevalence.

7.3 Correcting for Classification Bias Due to Measurement Error

Homes were classified as having LBP and lead hazards based on the XRF readings of paint and the analysis of dust and soil samples. Random variation, due to both instrument and laboratory variation and random selection of sampling locations, can induce a classification bias resulting in a bias in the estimated prevalence of HUs with LBP and lead hazards. In addition, paint and dust measurements were made in a sample of rooms – not all rooms. Under this protocol, it is possible for a home to have LBP or a LBP dust hazard in the unsampled rooms and non-lead-based paint and/or no dust-lead hazard in the sampled rooms. Such HUs would be incorrectly classified as not having LBP and/or LBP hazards (false negatives).

The measurement error adjusted values (lead loading or concentration) have, to the extent possible, the same distribution as the true lead loading or lead concentration values, without the effect of measurement error. The measurement error corrected values are a weighted average of the observed measurements and predicted values from a regression model. Calculating the weights requires modeling the magnitude of the measurement error variance and the regression error variance. Replicate measurements were used to estimate the measurement error variance. The measurement error adjustment

procedures include an algorithm for identifying outliers. The regression weights for the outliers were reduced to minimize their effect on the results.

The procedures used and findings for the measurement error analyses for paint, dust, and soil are discussed below in Sections 7.3.1 through 7.3.3. The specific procedures, equations, and justification for measurement error correction are presented in Appendix C of Volume II.

7.3.1 Measurement Error - Paint XRF Measurements

XRF readings to measure paint lead loading were taken on painted surfaces within the sampled rooms to assess the lead loading in paint. If there was more than one door or window in a room, one door was randomly selected or one window was randomly selected for XRF measurement. XRF readings were also taken on accessible exterior surfaces on two sides of the building. The measurement error adjustment procedures were first applied to the interior XRF readings. Because the measurement error adjusted XRF values are very close to the original XRF readings, the measurement error adjustment was not applied to the exterior XRF readings.

For the measurement error analysis for paint lead measurements, the objective was to determine the number and percentage of homes with LBP. A surface with LBP is a surface with an average lead loading across the surface of 1.0 mg/cm^2 or greater. According to the Niton XRF XL-309 Performance Characteristic Sheet, a surface is assumed to have LBP if the XRF reading is 1.0 mg/cm^2 or greater. The instrument calculates its best internal estimate of the lead loading, which it rounds to the nearest 0.1 mg/cm^2 for display. Therefore, to classify surfaces in an equivalent manner, the error corrected XRF readings were rounded to the nearest tenth unit for classifying surfaces.[37] The classification of surfaces as having or not having LBP is used to classify homes as having or not having LBP.

The measurement error adjustment procedure assumes that the distribution of the true paint lead loading around the average for similar homes and the distribution of the measurement error are normal. Although this assumption provides a reasonable description of the dust and soil measurements, it provides a relatively poor description of the XRF readings. As a result, the measurement error adjustment for paint lead loadings should be considered approximate, at best. Additional research into the

[37] Rounding to the nearest tenth unit for classifying surfaces is equivalent to classifying a surfaces as having LBP if the average lead loading across the surface is 0.95 or greater.

measurement error of the XRF instrument and the distribution of paint lead loading across components would be required to improve the measurement error adjusted values.

Figure 7.1, which shows a scatter plot of replicate XRF readings, helps to illustrate the distribution of the XRF readings. Note that the axes use the transformed scale used for the analysis (see Equation 9 in Appendix C of Volume II). The original XRF reading is on the horizontal axis and the replicate reading is on the vertical axis. Note that, 1) both XRF readings are zero for 72.3 percent of the replicate pairs, these pairs provide essentially no information about measurement error on surfaces with paint lead, 2) one XRF reading is zero in 12.4 percent of the replicate pairs, these pairs fall on the axes, and 3) both XRF readings are non-zero for 15.3 percent of the replicate pairs.

Replicate pairs for which both XRF readings are non-zero generally fall on the diagonal in Figure 7.1. For these points, the differences between the replicate XRF readings have an approximately normal distribution as assumed by the measurement error correction procedure. However, there are still numerous pairs for which the difference is notably larger than for the majority of data.

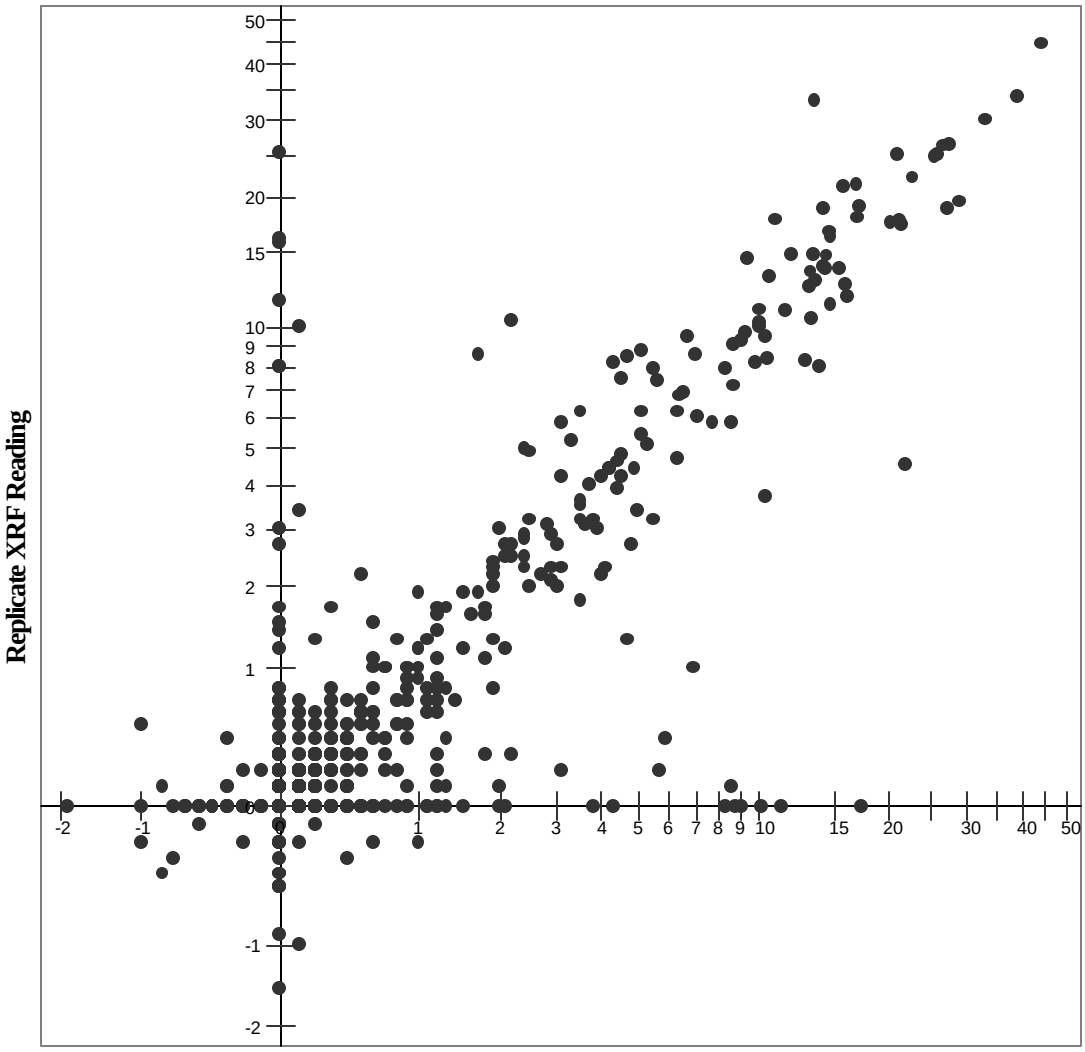
The XRF variation among all surfaces within a home increases with the average XRF reading within the home. This suggests that the measurement error will also increase with the paint lead loading on a component. Surfaces with lead loading near zero will have relatively precise measurements and we expect that large differences between replicate readings when one reading is zero will be relatively rare. However, there are many surfaces for which one reading is zero and the other paired reading is relatively large. The cluster of points along the axes is also inconsistent with the cluster of points along the diagonal in Figure 7.1.

The large differences may be due to two different parts of a component having very different paint lead loadings. Whatever the explanation for the pattern in the data, the patterns are not consistent with the assumptions behind the measurement error adjustment. Since no consistent pattern has been found that would provide a better model, the measurement error adjustment as described in Appendix C (Volume II) was applied to the data. The results provide one estimate of the effect of measurement error on the assessment of the number of homes with LBP. However, other assumptions or other modeling approaches may provide very different estimates of the magnitude of the effect of measurement error.

For the measurement error adjustment, homes in which all XRF readings were zero or negative (162) were assumed to have no paint lead. The remaining homes were used in the measurement error analysis. For those homes, the model used to predict paint lead loadings had factors for housing unit

ID, room type, year of construction, and interactions of year of construction by substrate, component, and percent deteriorated paint. A preliminary analysis suggested that the relationship between paint deterioration and XRF reading was not linear. To make the relationship closer to linear, the cube of the percent deterioration was used in the model. A further analysis of the relationship would be necessary to provide a better model.

Figure 7.1 Original and Replicate XRF Readings on the Same Component

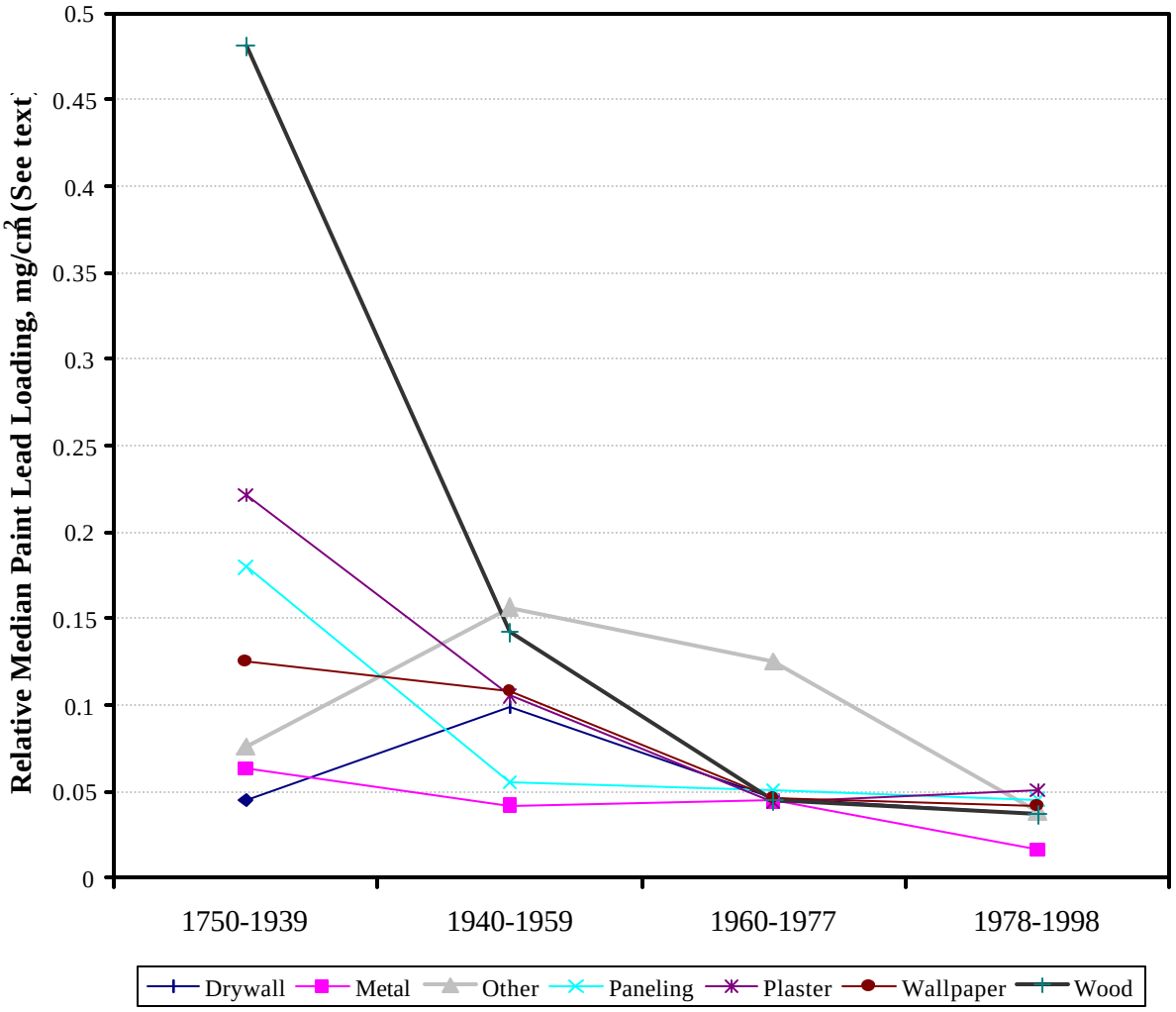


The model development to identify potentially significant factors used various household characteristics in place of the household ID. The results from that model illustrate patterns in the data that are presented below.

The regression analysis predicts the approximate median of the paint lead loading. Figure 7.2 shows the relative median paint lead loading estimated from regression, by construction year category and component substrate. The values in Figure 7.2 assume values for the other parameters that correspond to equal representation of all types of homes[38]. Although this assumed distribution of homes may not be of interest, the relative paint loadings in Figure 7.2 illustrate the relative differences predicted by the regression model. In a similar manner, Figure 7.3 shows the relative differences in median paint lead loading associated with combinations of construction year and region of the country. Figure 7.4 and 7.5 shows the relative differences in the median paint lead loading versus component type, room type, component condition, metro status, presence of pets, overall cleanliness, and the number of days the air conditioning was used in the last month.

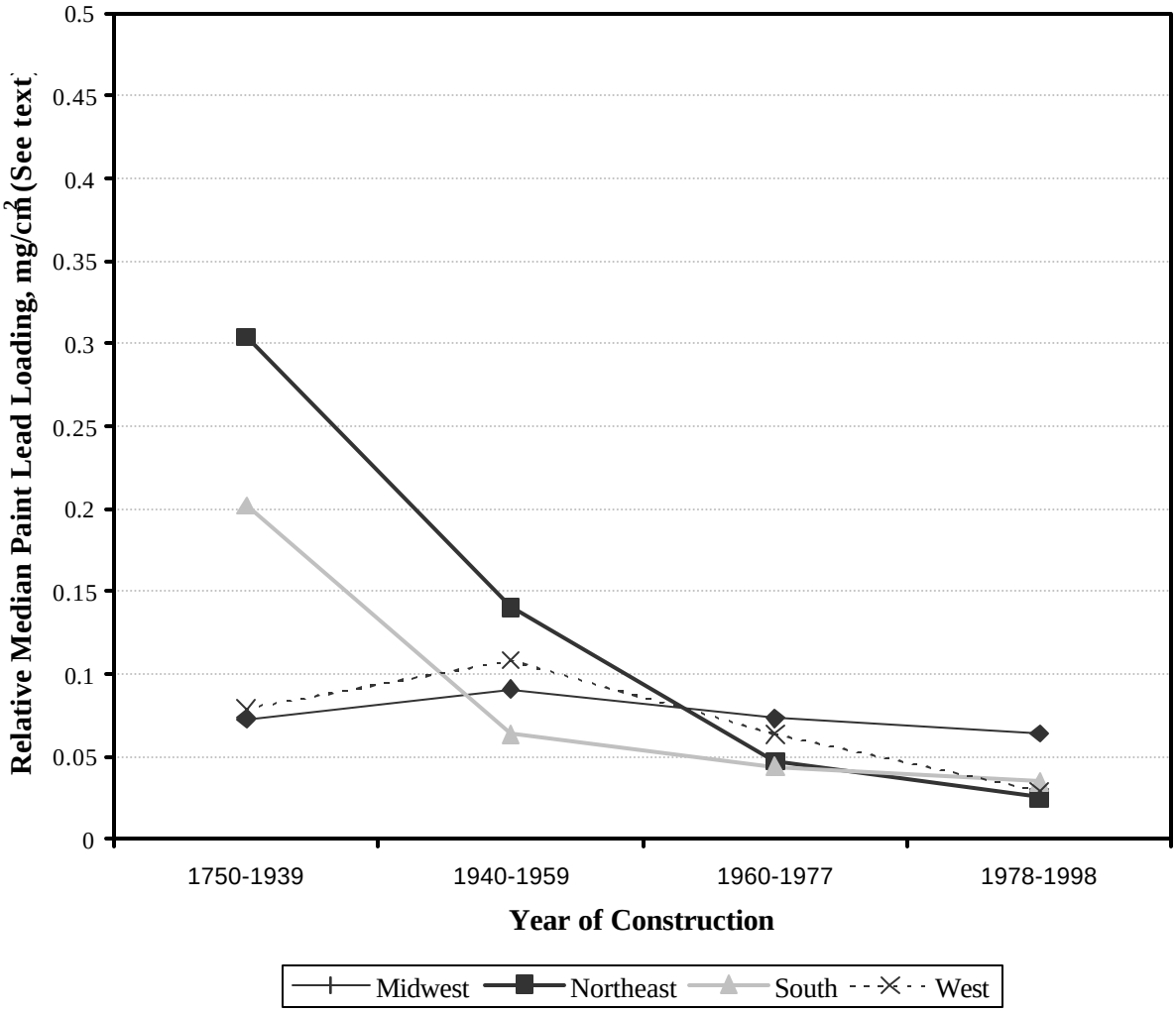
[38] These values are the least square means from SAS PROC GLM, transformed back to the measurement units.

Figure 7.2 Relative Median Paint Lead Loading by Construction Year of the Home and Substrate



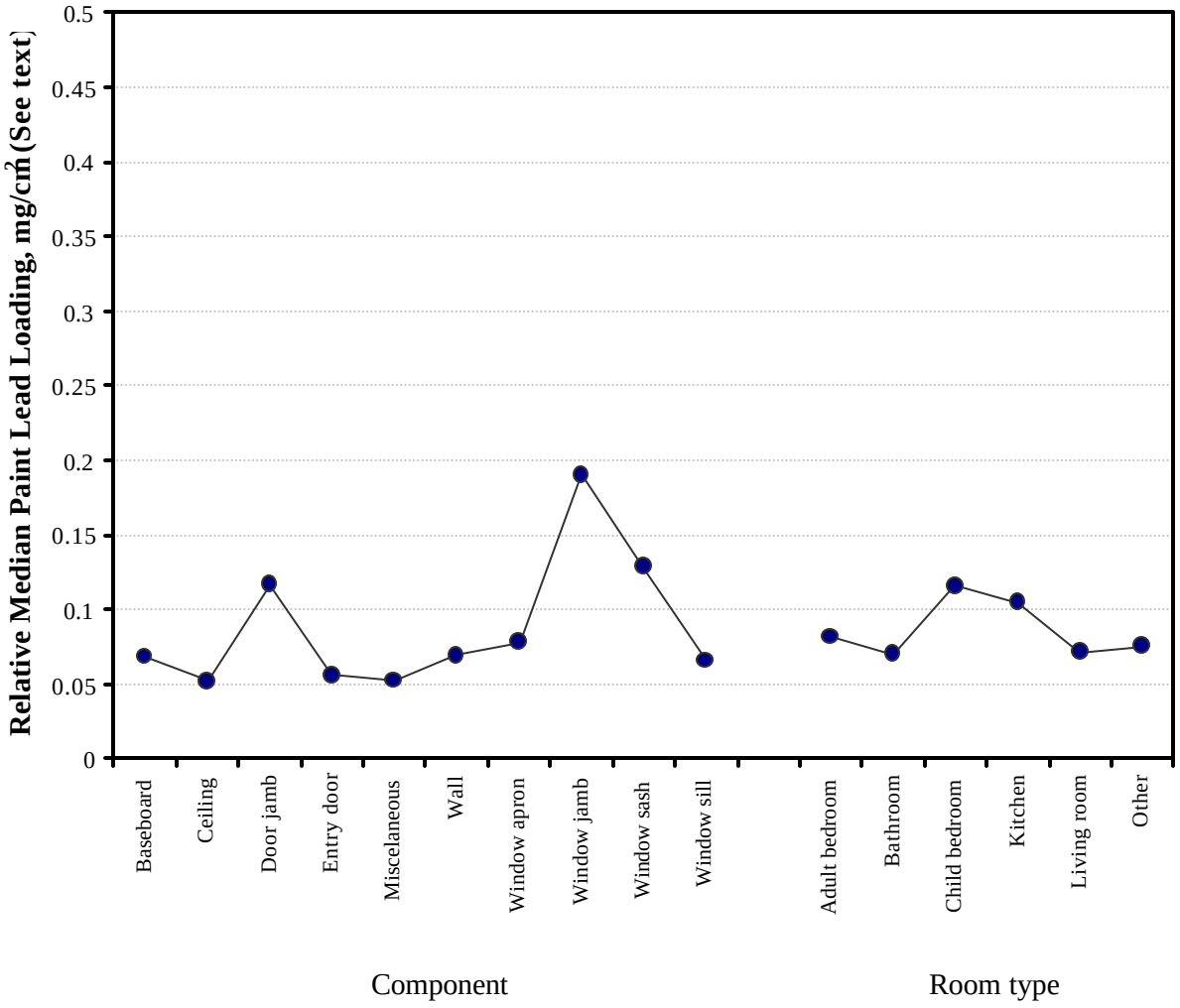
Overall, paint lead loadings are highest in the oldest homes and lowest in the newest homes. The patterns for paint lead loading on specific substrates also generally decrease with the age of the home. The paint lead loadings are highest on wood surfaces in the oldest homes. For components with drywall, paneling, metal, plaster, wallpaper, and wood substrates, the median paint lead loading is low (less than 0.05 mg/cm^2) for homes built since 1960. However, median paint lead loading on other substrates (such as brick, concrete, stone, and vinyl) are higher for homes built in the 1960 to 1977 period.

Figure 7.3 Relative Median Paint Lead Loading by Construction Year of the Home and Region



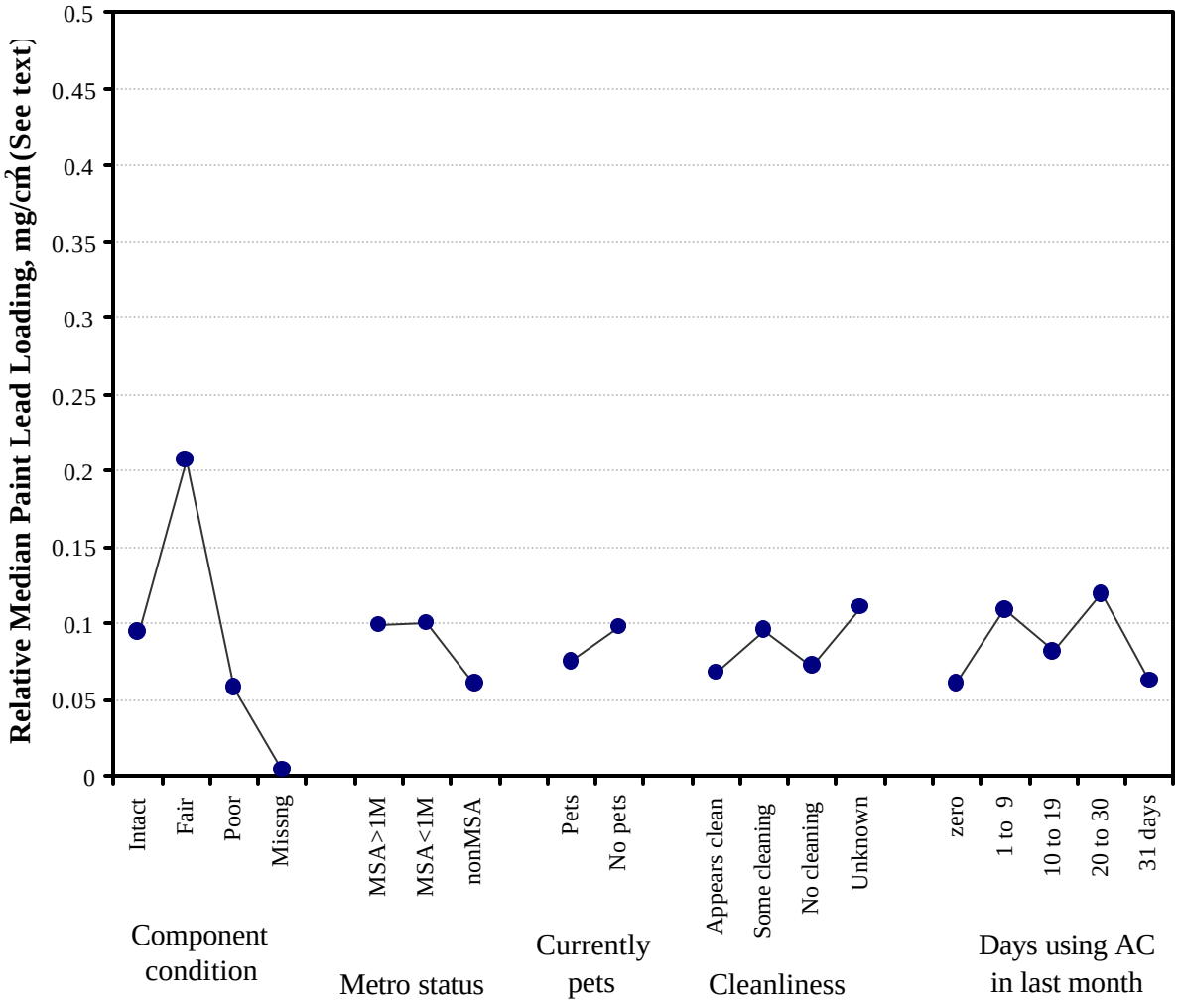
The highest median paint lead loading is found in homes built before 1960 in the northeast US and in homes built before 1940 in the southern US.

Figure 7.4 Relative Median Paint Lead Loading by Component Type and Room Type



Higher paint lead loadings are generally found on doors, window jambs and window sashes. There are relatively small but significant differences in the paint lead loading among rooms of different types. After accounting for other factors, paint lead loadings are generally higher in children's bedrooms and in kitchens.

Figure 7.5 Relative Median Paint Lead Loading by Component Condition, Metro Status, Presence of Pets, Overall Cleanliness, and Air Condition Use in the Last Month



Higher paint lead loadings are generally found on components that were judged to be in fair condition as opposed to intact or poor condition. However, relatively few surfaces were judged to be in fair condition. Small but significant differences were associated with metro status (lower paint lead loading in non-MSAs), presence of pets (lower in homes with pets), overall cleanliness, and days using air conditioning in the last month.

As part of the exploratory analysis to identify the model for the data, such additional variables as tenure and race were considered and not found to be significant predictors.

The measurement error adjustment procedure identified approximately 30 percent of the XRF readings as outliers. Outliers are those measurements that are more than 2.5 standard deviations above or below the mean of the non-outliers. The high proportion of outliers reflects the fact that the measurement error procedure's assummed normal distribution was a poor description of the distribution of the XRF readings. In this case, the measurement error procedure makes a conservative adjustment. The non-outlier data were assumed to have a normal error distribution, however, the distribution of the residuals had a tight distribution in the center and very long tails, inconsistent with the normal distribution assumption. The resulting estimate of the error variance was very small, resulting in almost no estimated effect of measurement error. Using the measurement error procedure in Appendix C (Volume II), the measurement error adjusted paint lead loadings are essentially equal to the XRF readings. Additional work would be required to develop a better model for the XRF readings and other assumptions might provide a significantly different assessment of the effects of measurement error.

The tentative results from the measurement error analysis are that the interior XRF readings provide a reasonable measure of the paint lead loading for many surfaces. For the remaining surfaces that look like outliers when judged relative to a normal distribution, the effect of measurement error is difficult to assess. We believe that similar conclusions are likely to apply to exterior surfaces, however, no measurement error adjustment was attempted for the exterior surfaces.

7.3.2 Measurement Error – Dust Lead Measurements

Dust samples were taken at all surveyed homes from the floor at the main entrance and from the floors, window sills, and window troughs of the sampled rooms. Separate measurement error adjustments were performed for the floor and window dust samples.

Floor Dust Lead Loading

The model for predicting floor dust lead loading included factors for household ID (as a class variable), surface characteristics at the sample location, and the interaction of the type of floor cover and year of construction. Two homes had no floor dust lead loading measurements. For predicting floor dust lead loading in these homes, a second model was used with factors for year of construction, household income, overall household cleanliness, surface characteristics at the sample location, and the interaction of the type of floor cover and year of construction.

The regression analysis predicts the approximate median of the soil lead concentrations. Figure 7.6 shows the relative median floor dust lead loading estimated from regression, by construction year category and type of floor cover in the sampled room. The values in Figure 7.6 assume values for the other parameters that correspond to equal representation of all types of homes. Although this assumed distribution of homes may not be of interest, the relative floor dust loadings in Figure 7.6 illustrate the relative differences predicted by the regression model. In a similar manner, Figure 7.7 shows the relative differences in median floor dust lead loading associated with different levels of household cleanliness, household income, and surface condition.

The predicted median floor dust lead loadings are highest for the oldest homes and decrease for homes constructed more recently. The floor lead loading is generally higher in rooms with no floor covering (mats, throw rugs, carpets, etc.) than in rooms with wall-to-wall carpets. Rooms with some floor covering have floor dust loadings similar to or somewhat greater then in rooms with wall-to-wall carpets, and lower than rooms with no floor covering. The floor covering was not recorded for some rooms and was not requested as part of the survey for the main entrance sample. The floor lead loadings for the unknown floor cover category represent primarily the floor dust lead loadings for the main entrance (94% of the data in the unknown category). The dust lead loading at the main entrance is similar to dust lead loading from other rooms which have no floor covering. As shown in Figure 7.7, dust lead loadings are on average higher in lower income homes

The field staff were asked to rate the cleanliness and clutter of each home. Cleanliness was categorized as 1) appears clean, 2) some evidence of housecleaning, and 3) No evidence of housecleaning. In addition, the respondents were asked how recently different rooms within the house were cleaned, and how. This data was summarized for each home using the median number of days since cleaning, across all rooms for which values were reported. Finally, the surface from which the dust sample was taken was categorized as carpeted, smooth and cleanable, or not smooth and cleanable. The regression results show that the floor dust lead loadings are significantly higher in homes that show no evidence of cleaning (a small minority of all homes) compared to homes with some evidence of cleaning. Dust lead loadings are also higher on hard surfaces that are not smooth and cleanable (a small minority of all surfaces), perhaps because these surfaces are more difficult to clean or perhaps because they collect dust faster between cleanings. Carpets have lower lead loading than smooth and cleanable surfaces, using the sampling methods employed. These results suggest that cleaning activity will generally affect dust lead loading. However, the number of days since last cleaning may not be a good measure of the effect of cleaning on dust lead loading.

As part of the exploratory analysis to identify the model for the data, additional variables were considered and not found to be significant predictors. In particular, the type of room (bedroom, bathroom, kitchen, etc.) and presence of pets were not significant.

Figure 7.6 Relative Median Floor Dust Lead Loadings Estimated from Regression, by Construction Year Category and Floor Cover in the Sampled Room

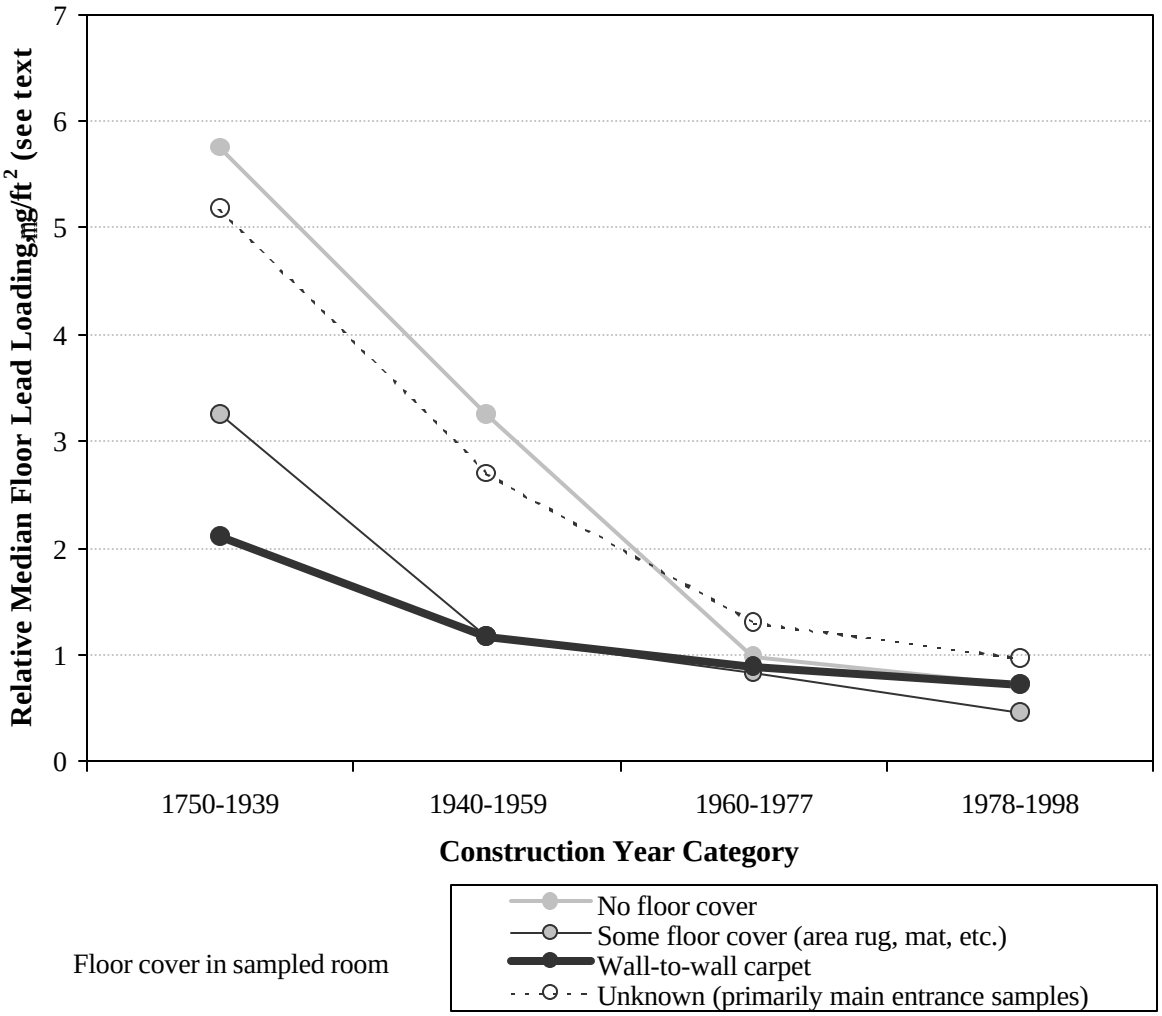


Figure 7.7 Relative Median Floor Dust Lead Loadings Estimated from Regression, by Cleanliness, Household Income, and Surface Condition

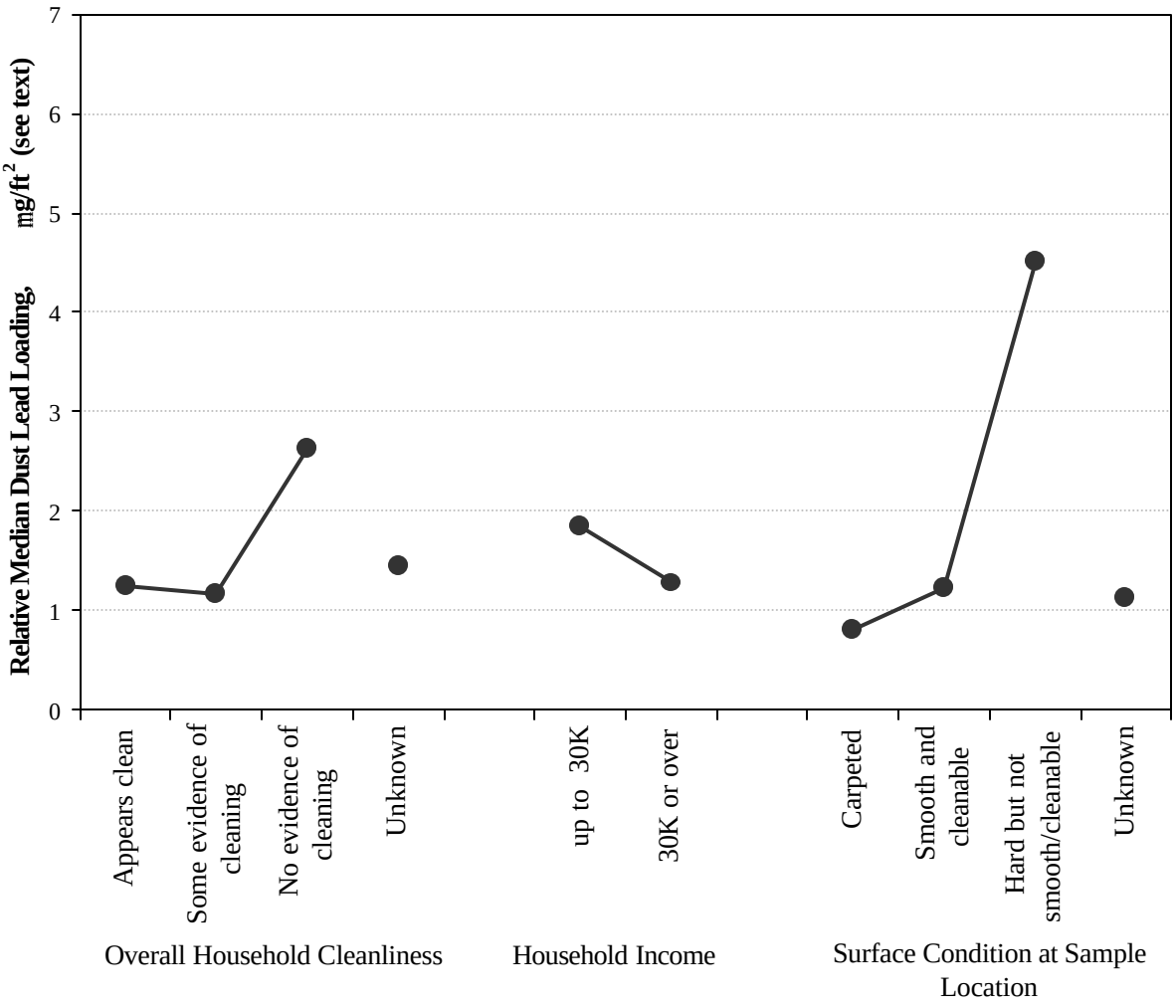


Figure 7.8 shows the cumulative distribution of the maximum floor dust lead loading at homes. The figure shows three cumulative distributions:

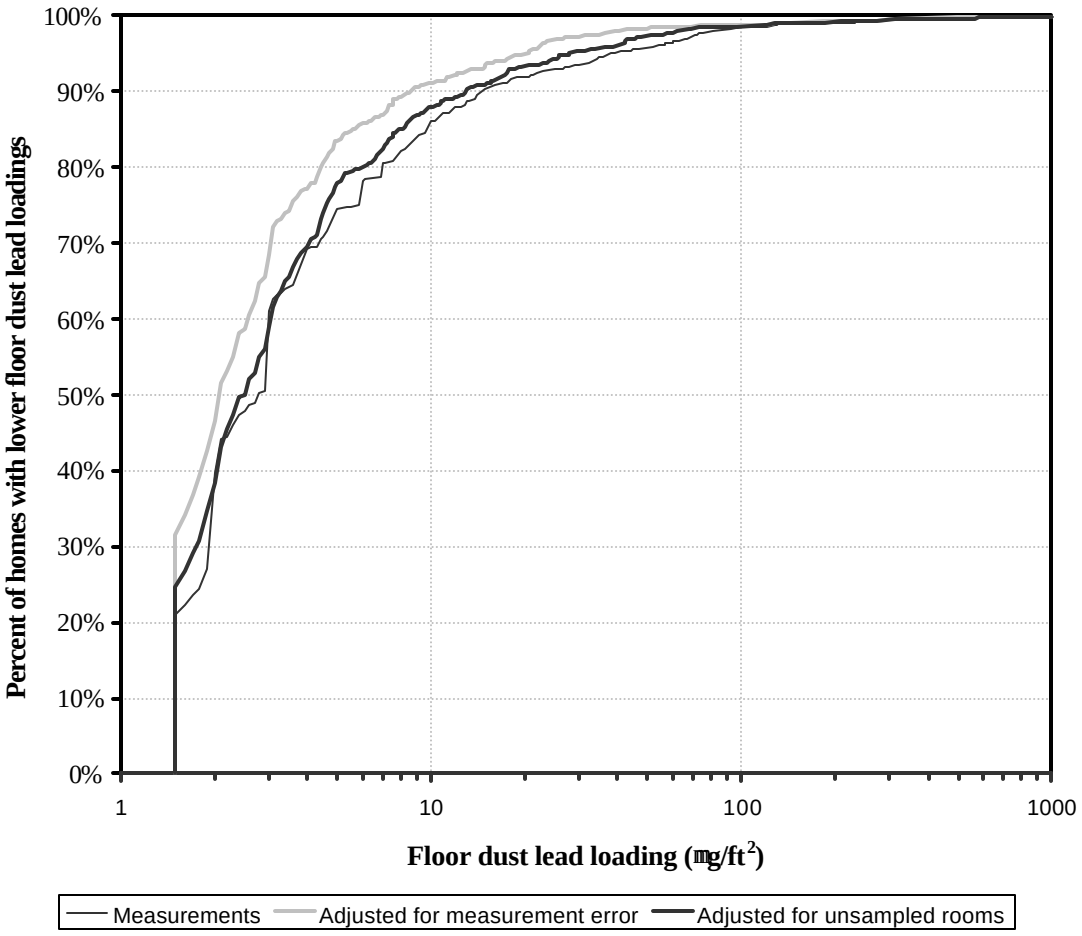
1. The maximum of the floor dust lead loading measurements at a home (bottom thin black line).

2. The maximum measurement error adjusted floor dust lead loading across the sampled rooms (gray line).

3. The maximum measurement error adjusted floor dust lead loading across all rooms, sampled and unsampled (thick black line).

The difference between the first and second curves shows the effect of the measurement error adjustment on the classification of the measured surfaces. The difference between the second (thick gray line) and the third (thick black line) curves illustrates the effect of random selection of rooms on the classification of homes. Measurement error tends to increase the number of homes and incomplete sampling of rooms tends to decrease the number of homes classified as having maximum floor dust lead loading above a selected value. For the floor data, these effects partially cancel out so that the number of homes classified as having floor lead over a specified value using either the maximum adjusted lead loading value or the maximum observed measurements is similar. The difference between the first (thin black line) and the third (thick black line) curves illustrates the combined effect of doing both the measurement-error adjustment and unsampled-room adjustment.

Figure 7.8 Cumulative Distribution of the Maximum Floor Dust Lead Loading for Homes



Using the measurement error corrected values, an estimated four percent of homes (about 4 million homes) have floor dust lead loadings of 40 $\mu g/ft^2$ or more in one or more rooms. This is about one percent fewer homes than estimated using the floor dust measurements.

Window Dust Lead Loading

Window dust samples were taken from randomly selected windows in the sampled rooms within surveyed homes. For the measurement error correction, one objective was to estimate the number of rooms having or not having average window sill dust lead loading and average window trough dust lead loading less than a selected value. A second objective was to estimate the number of homes with average room window sill and window trough dust lead loading less than a selected value in all rooms. The first objective required estimating lead loadings for the missing values and adjusting for measurement error. The second objective also required adjusting for the unknown lead loading in the unsampled rooms.

The analysis below used both the window sill dust lead and window trough data dust lead loadings in the same model for calculating the measurement error adjustment. Because the log transformation was used, the model assumes that the same factors predict the relative sill and trough lead loadings and that the ratio of the sill to trough lead loading was constant across homes. This model appeared to be consistent with the data. Although a separate measurement error adjustment could have been performed separately for sill and trough measurements, this combined approach was expected to provide a similar adjustment.

Two models were fit to the data. One was used for predicting window dust lead loading in homes with at least one window lead loading measurement. A second model was used to predict window dust lead loading for homes with no window dust lead loading measurements in the data files. The predictors in each model are presented in Table 7.4.

Table 7.4 Regression Model Used for Different Categories of Homes

Category of homes	Number of homes	Factors for predicting window dust lead loading
I. Homes with no window dust samples	17	Sample location (sill or trough), year of construction, tenure, race category of occupants, overall household cleanliness as judged by the interviewer, and room type.
II. Homes with at least one window dust sample	808	Sample location (sill or trough), household ID (as a class variable), surface characteristics at the sample location, whether the window has a vinyl mini-blind, and room type.

The regression analysis predicts the approximate median of the dust lead concentrations as a function of the independent variables. The relative effect of any one independent variable on the predicted dust lead concentration can be illustrated by assuming fixed values for all other independent variables. Figure 7.9 shows the relative differences in median window dust lead loading associated with different levels of sample location (sill or trough), year of construction, tenure, race category, overall household cleanliness, surface characteristics, room type, and presence of vinyl mini-blinds. These relative median dust lead concentrations assume that all other parameters are equal to their mean or, equivalently, that homes are distributed evenly among the levels of all variables. Although this assumed distribution of homes may not be of particular interest, the relative window dust loadings in Figure 7.9 illustrate the relative differences predicted by the regression model. For example, in Figure 7.9 the ratio of the window trough to window sill dust lead loading is 13.2. The model assumes that this ratio is the same for both old and new homes. The ratio of the window dust loading in homes built from 1750 to 1939 to homes built from 1940 to 1959 is 3.6. The model assumes that this ratio is the same for window sill dust (with lead loadings around 70) and for window trough dust (with lead loadings around 1000). The values shown in Figure 7.9 were derived from the first model in Table 7.4 with two additional predictors added, surface characteristics at the sample location and presence of vinyl mini-blinds. These two terms were not included in the model for predicting lead loading in homes without data, because there was generally no information on these predictors for these homes.

The predicted median window dust lead loading is much higher in the window trough than on the window sill. Lead loading is highest for the oldest homes and lower for homes constructed more recently. The window lead loading is generally higher rented homes than in private owned homes and higher in homes with African American residents and in homes with residents of other races. The small number of homes that have no apparent indication of cleaning have higher window dust lead loadings than

homes that were classified as showing some evidence of cleaning or appearing clean. Although most rooms had similar window dust lead loading measurements, measurements were somewhat higher in adult bedrooms and "Other" rooms (rooms not classified as kitchen, living room, bedroom, or bathroom). Samples from window surfaces that were not smooth and cleanable had higher lead loading than samples from smooth and cleanable surfaces. Finally, windows with vinyl mini-blinds had somewhat higher dust lead loading than windows without vinyl mini-blinds. Differences for other window coverings were not statistically significant.

Figure 7.9 Median Window Dust Lead Loading Estimated from Regression by Different Factors in the Regression Model

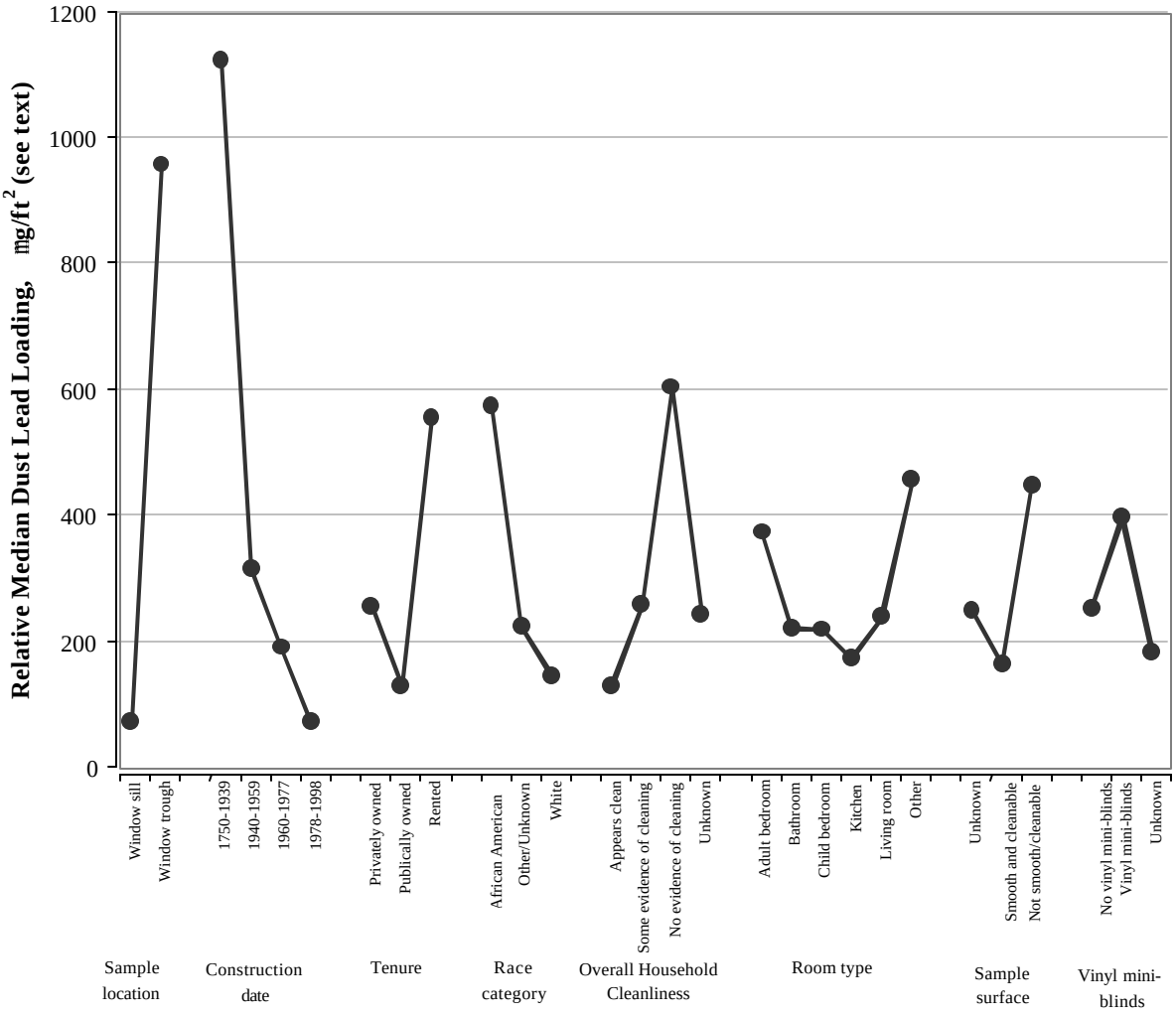


Figure 7.10 shows the cumulative distribution of the maximum window sill dust lead loading within homes. The figure shows four cumulative distributions:

1. The maximum of the window dust lead loading measurements within a home (thin black line).

2. The maximum of the window dust lead loading measurements or predicted values for missing data (also a thin black line).

3. The maximum measurement-error-adjusted window dust lead loading across the sampled rooms (thick gray line).

4. The maximum measurement-error-adjusted window dust lead loading across all rooms, sampled and unsampled (thick black line).

For various reasons, for example inaccessible surfaces, data are not available for some window surfaces. The first curve assumes that the lead loading on all surfaces with missing data is negligible. As a result of the measurement error adjustment, predicted values are available for all surfaces. For surfaces with no data, the predicted values were used. The second curve, to the right of the first curve, shows the cumulative distribution of the best estimate of the lead loading on all window surfaces, i.e., the measurement on surfaces with data and the predicted values on surfaces with no measurements. The predicted values are referred to as imputed values. The imputation generally affects the lower portion of the distribution.

The third curve shows the distribution of the measurement error adjusted estimates. Since measurement error will generally increase the maximum within-home measurements, the effect of the measurement error correction is to slightly reduce estimated maximum within-home window dust lead loading. The fourth curve shows the cumulative distribution of the measurement error corrected measurements after accounting for the incomplete sampling of rooms. These values will be referred to as the adjusted values. The primary difference between the maximum of the observed window sill dust lead loading measurements and the final adjusted maximum in each home is due to the incomplete sampling of rooms.

Using the adjusted values, an estimated 19 percent of homes (18 million homes) have a window sill dust lead loading of at least 250 $\mu g/ft^2$ in at least one room. This is about five percent more homes than estimated using the measurements.

Figure 7.10 Cumulative Distribution of the Maximum Within-Home Window Sill Dust Lead Loading

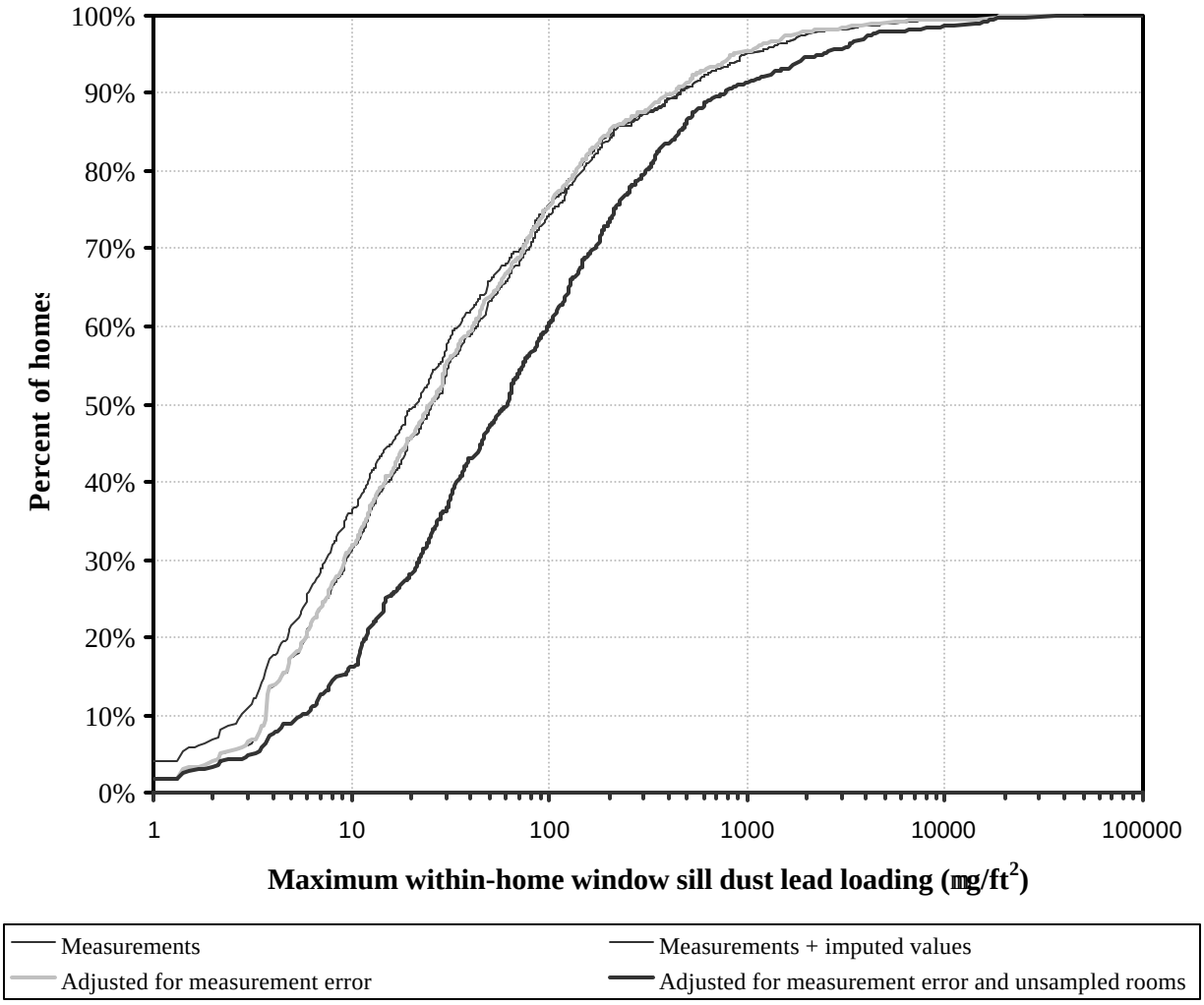
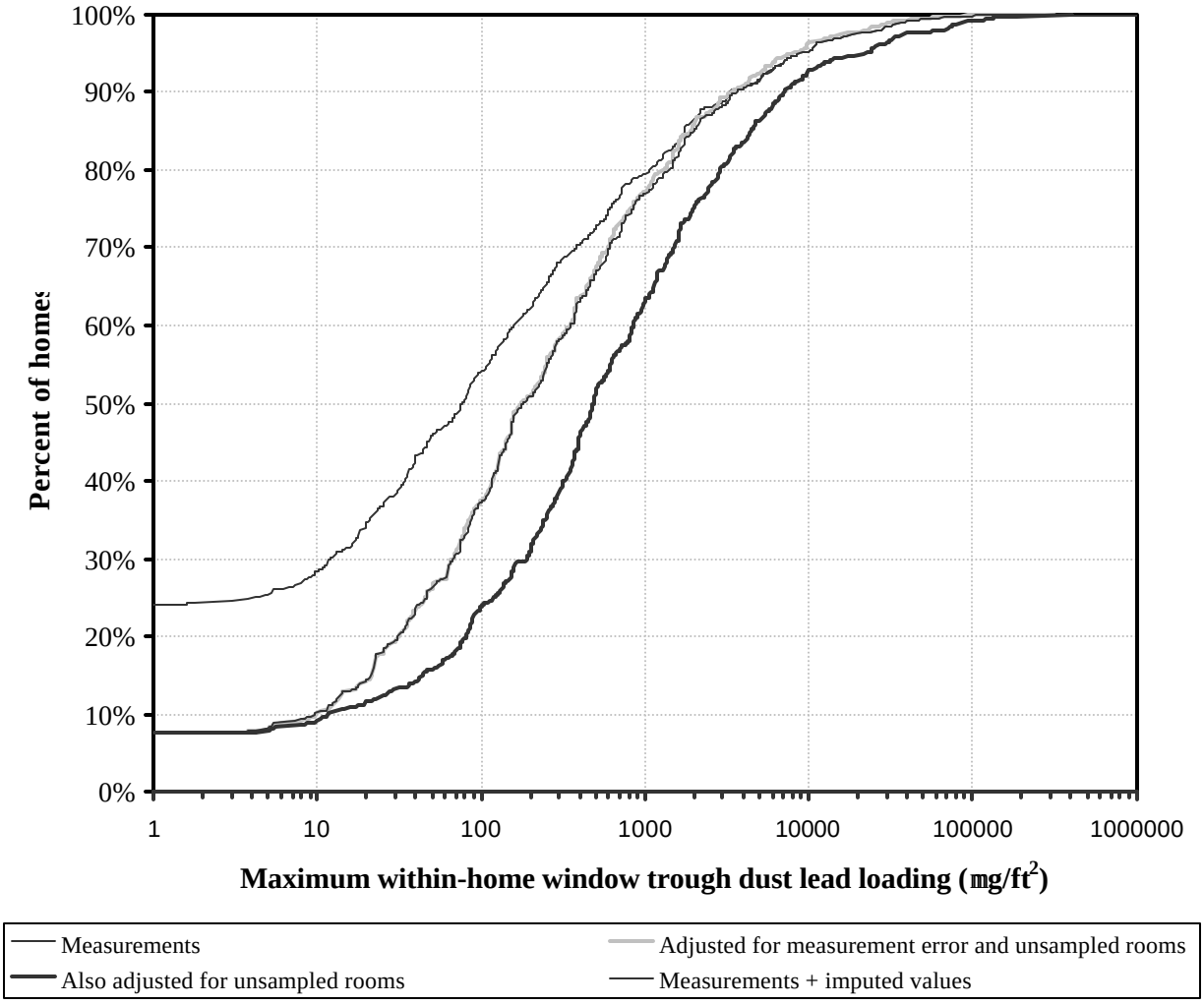


Figure 7.11 shows the cumulative distribution of the maximum window trough dust lead loading within homes. The figure shows four cumulative distributions for the measurements (thin upper thin black line), the measurements plus imputed values (lower thin black line), the measurement error corrected values for the sampled rooms (gray line) and the final adjusted values that account for the incomplete sampling of rooms

Because there were many surfaces for which window trough data could not be obtained, there are relatively large differences between the distributions for the measurements and the measurements with imputed values. As with the window sill lead loading, the measurement error

adjustment for the available measurements makes only a small difference compared to the effect of missing data and the incomplete sampling of rooms.

Figure 7.11 Cumulative Distribution of the Maximum Within-Home Window Trough Dust Lead Loading



7.3.3 Measurement Error – Soil Lead Measurements

Soil samples were taken at all surveyed homes at the major entrance and along the dripline and midyard of two sides of the home, if soil was present. For the soil measurement error correction, the

objective was to determine the number and percentage of homes with average soil lead concentrations above a selected value at the three sample sites - midyard, dripline, and main entrance[39].

Table 7.5 describes the regression model used for different categories of homes.

- For Category I homes, there was no soil at any of the three sample sites, and so no model was required. This situation occurred if all areas of the yard were covered with concrete, asphalt, or rock. Also, a specific sample site could have no soil if the site did not exist (for example, the dripline and the property line coincided so that there was no midyard sample site).

- For Category II homes, at least one of the sample sites had soil, but there were no soil lead measurements for the home. This situation could arise if the respondent denied permission to collect soil samples, or if adverse conditions existed, such as an ongoing storm, frozen ground, the presence of a dog, or large rocks mixed in with the soil. The measurement error corrected soil lead concentrations are the predicted values from the regression model.

- For Category III homes, all soil measurements were equal to zero. While the sample detection limit was determined to be 20 ppm, the laboratory provided an estimate of the soil lead for all samples with levels below the detection limit. However, negative laboratory estimates were reported as zero. The measurement error corrected soil lead concentrations are assumed to be less than the detection limit.

- For Category IV homes, some or all of the soil measurements were equal to a non-zero value (i.e., a value at or more than the detection limit). These values were used to predict soil lead concentrations for the category IV and category II homes.

[39] The average of the available midyard and average of available dripline samples were used for the measurement error analysis, regardless of which side of the house they were collected. That is, separate assessments were not made for midyard and dripline areas on each side of the home.

Table 7.5 Regression Model Used for Different Categories of Homes

Category of homes	Number of homes	Model for measurement error corrected soil concentrations
I. Homes with no soil at any sample site	45	Not applicable.
II. Homes with soil, but no soil measurements	8	Log transformed soil lead concentration = a mean for each combination of construction year category and soil sample location and a mean for each combination of construction year category and region.
III. Homes with all soil lead measurements equal to zero (therefore no within-home variation)	33	All measurements assumed to be less than the detection limit.
IV. Homes with soil lead measurements, some or all of which are non-zero	745	Log transformed soil lead concentration = a mean for each combination of construction year category and soil sample location, a mean for each combination of construction year category and region, and a mean for each home

The regression analysis predicts the approximate median of the soil lead concentrations. (The mean of the log transformed data is the median of the non-transformed data.) Figures 7.12 and 7.13 show the relative median soil lead concentration for homes within each construction year category by sample location and region. As expected, older homes have higher soil lead concentrations. Concentrations are also higher on average in the northeast region and lower in the western region of the country. Soil lead concentrations are higher on average at the dripline sample location and lower at the midyard sample location.

As part of the exploratory analysis to identify the model for the data, additional variables were considered. In particular, orientation of the side of the building (north, east, south, or west) and ground cover (bare soil, grass, ivy, moss, mulch, and other or unknown) were examined. Neither the side of the house on which the samples were taken nor the ground cover was a significant predictor of soil lead concentrations, after adjusting for the effects of year of construction, region, and sample location.

Figure 7.12 Relative Median Soil Lead Concentrations Estimated from Regression, by Construction Year Category and Sample Location

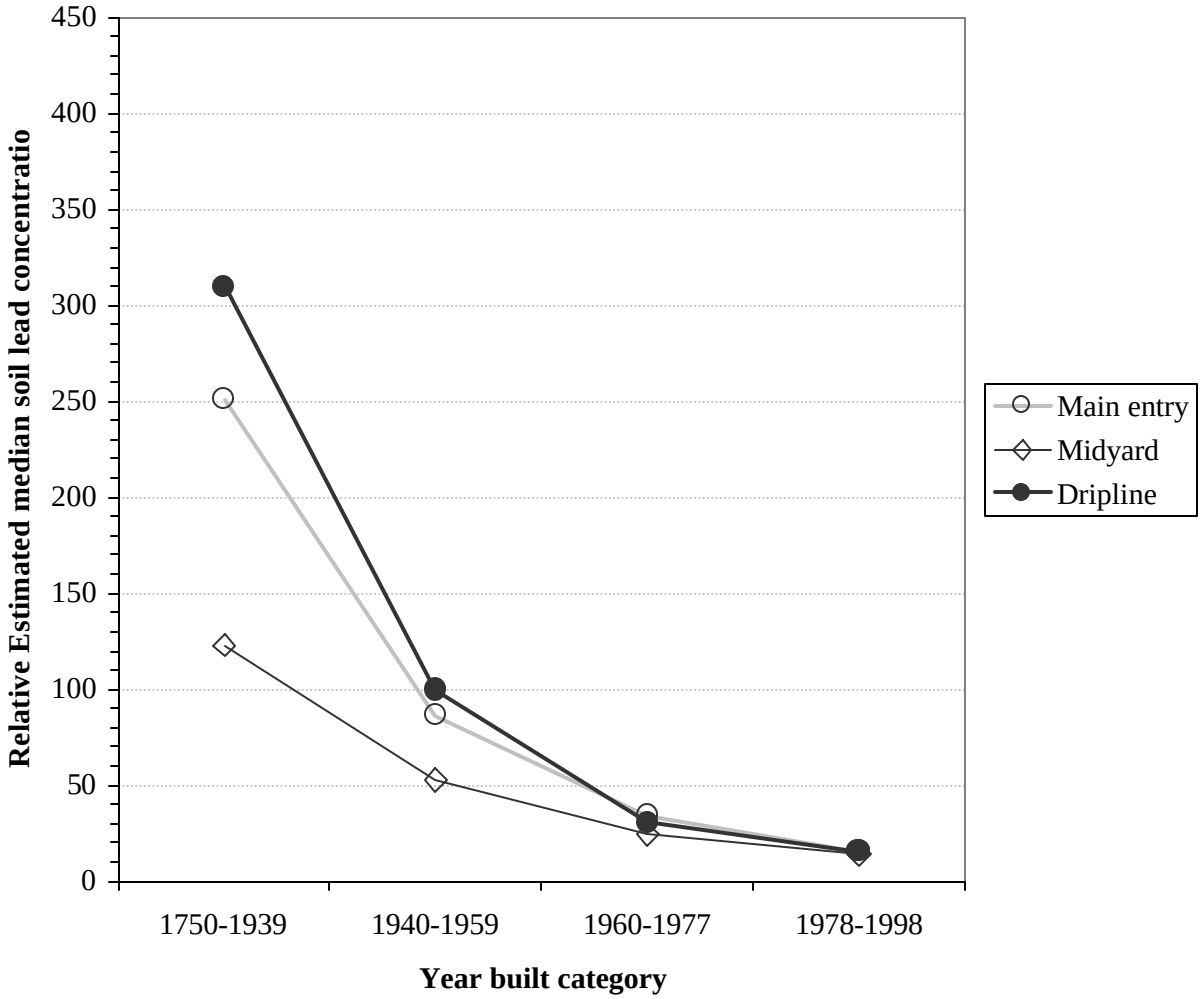


Figure 7.13 Median Soil Lead Concentrations Estimated from Regression, by Construction Year Category and Region

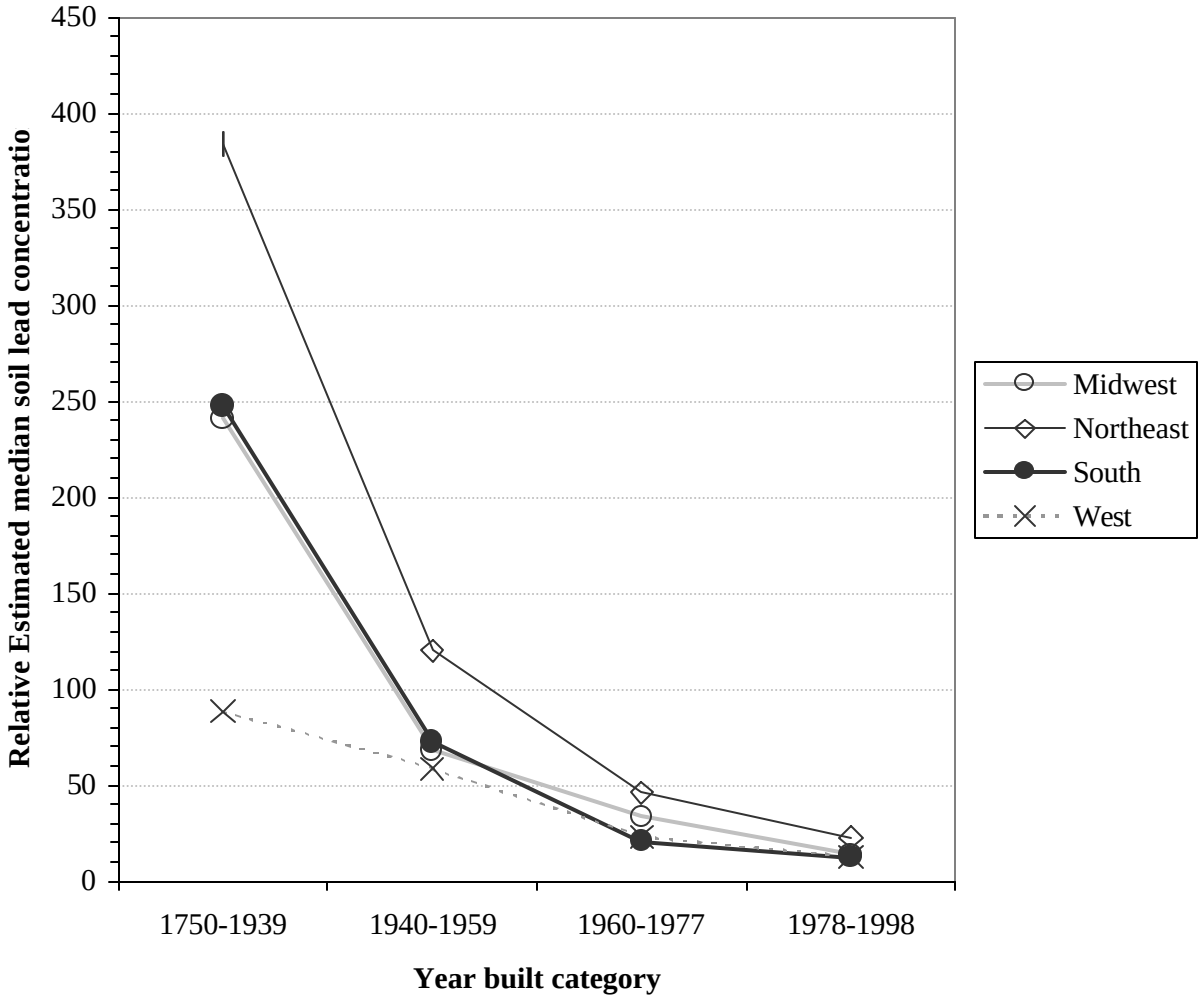
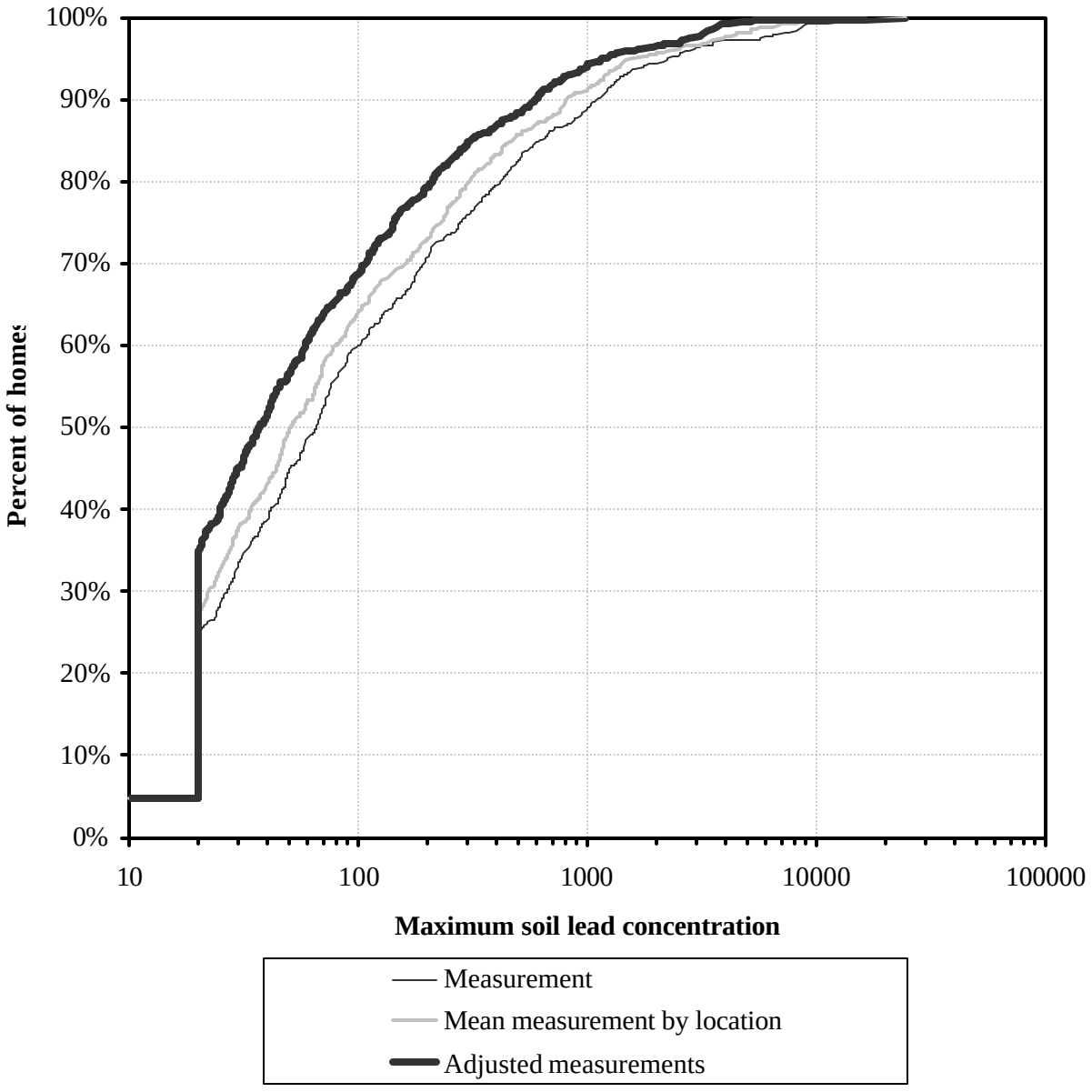


Figure 7.14 shows the cumulative distribution of the maximum soil lead concentration at homes. The figure shows three cumulative distributions:

- The maximum of the soil lead measurements at a home (bottom thin black line).
- The maximum within each home of the average soil lead measurements at the entrance, dripline, and midyard (middle gray line).

- The maximum measurement error corrected soil lead measurements (top thick black line).

Figure 7.14 Cumulative Distribution of the Maximum Soil Lead Concentration for All Homes



The difference between the first and second curves shows the effect of taking replicate soil measurements (i.e. more than one sample for a given sample location at a home). As more measurements are taken, it is more likely that a sample will be taken which has an unusually high

measurement (either due to laboratory variation or due to sampling a small area with a locally high concentration). The second curve is most comparable to the third curve. The difference between the second and the third curve is due to the measurement error correction. The fact that the third (measurement error corrected) curve is to the left of the other curve is because, after correcting for measurement error, the percentage of homes judged to have soil lead concentrations above any selected value is decreased.

Using the measurement error corrected values, an estimated 3.6 percent of homes with soil (about 3.4 million homes) have soil lead concentrations above 2,000 ppm in one or more of the sampling locations (dripline, midyard, and main entrance). This is about two million fewer homes than estimated using the observed soil lead measurements. Since (see Table 3.2) approximately one-sixth of homes with a LBP hazard also had an exterior hazard, this finding is unlikely to dramatically change the national estimate of homes with a LBP hazard. The measurement error percent reduction in homes with a LBP hazard is anticipated to be less for paint and dust than it is for soil.

7.4 Quality of Field Data Collection and Analysis

Quality assurance was integrated into all components of the study, including a defensible study design, experienced project personnel, utilization of well-planned, detailed and tested protocols for all aspects of data collection, thorough study-specific training of experienced field staff, electronic sample and data management, and ongoing communication between individuals responsible for each stage of the study. These procedures are described in detail in Volume II, Chapter 6.

Four types of replicate sampling were conducted to estimate measurement error: replicate XRF testing of one random component per room, replicate dust sampling of one surface per home, replicate soil sampling at a different sample site at every third home, and replicate room sampling at a subset of homes. The analyses utilizing these replicate data and resultant measurement error estimates are presented above in Section 7.3.

This section summarizes the results of the various activities focussed at ensuring quality of the field data collection and laboratory analysis of the environmental samples.

7.4.1 Field Data Collection

A number of procedures were instituted to ensure quality of the field data collection, including a manual edit of all data and samples by the field team, review by the Field Supervisor upon return of the data to Westat headquarters, and reconciliation of any errors with the field team prior to submission of any samples to the laboratory. In addition, random telephone verification and field team audits were conducted; dust sample material screens were analyzed; and dust blanks and spike samples and blind soil reference samples were included in the sample stream.

Telephone Verification of Data Collection

The Field Director contacted a random subsample of 82 (10%) households by telephone to verify the team's activities and conduct and to validate selected information from the data forms. No field problems were identified by this process.

In addition to the random verification process, a number of respondents and potential respondents utilized the toll-free phone number, or the HUD phone number, to ask questions, verify the survey, and express concerns. All questions or concerns were answered or addressed by the Field Director or HUD.

Random Field Audits

The QA Officer or designee, and HUD and NIEHS representatives, conducted random field audits at 31 households to verify that the protocols were followed and data collection was accurate and complete. In addition to the field audits, the QA Officer conducted 17 telephone audits to ascertain the team members' understanding of the protocols, especially when more than two months had elapsed between assignments. Problems noted during these audits were corrected directly with the individual team members. In addition, the results of audits were immediately relayed to the Field Office. As appropriate, all field staff were notified by memo of any issues identified with the protocols.

Lead Dust Wipe Sample Collection

- **Lead Dust Wipe Materials Screens**

The purpose of a materials screen was to verify that the various sampling supplies to be used in the field did not have lead contamination. Two screens were prepared and analyzed for every lot of wipe materials and sample tubes before being used in the study. The analyses showed that all material screens had below 1.5 µg lead.

- **Field Blank Wipes**

One field blank was prepared for each HU at a specified random sample location where another wipe sample was collected. All field blanks were below 50 µg lead/wipe, as specified in HUD *Guidelines*. Most field blanks had lead levels below the detection limit (of approximately 3.5 µg lead/wipe) for the analytical run. Of 45 field blanks with detectable lead values, only one blank had more than 20 µg lead/wipe; this was in a home with elevated window sill and trough lead dust levels. Data from this home were used in the survey since the blank was still well below the 50 µg guideline.

- **Reference (Spike) Sample Dust Wipes**

Reference wipe samples were made in advance of the fieldwork from the National Institute of Standards and Technology's Standard Reference Material (NIST SRM) 1579a. The reference wipes were labeled like a regular sample so that the laboratory was blinded to fact that these were quality control samples. The Field Office inserted one reference wipe sample with each group of 50 samples before sending samples to the laboratory. A total of 206 reference wipes, ranging from 21 to 516 µg lead/wipe, were submitted over the course of the study. The average reference sample recovery was 96% (range from 83% to 115%) with a standard deviation of $\pm$ 5.25 percent. With a few exceptions, all sample recoveries were within the HUD *Guidelines* acceptable range of 80 to 120 percent. The laboratory was requested to re-analyze these batches. Recoveries were acceptable on the second run (see Section 6.7 of Volume II of this report) and the second set of data was used for the entire batch of samples.

Soil Quality Control Samples

- **Reference Soil Samples**

Reference soil samples were purchased before the fieldwork began. The Field Office labeled and included one reference sample with each group of samples from every three households (approximately one sample in ten). A total of 83 soil reference samples were submitted to the laboratory. The average recovery was 104% (range 84% to 121%) with a standard deviation of $\pm$ 8.04 percent. Two analytical batches contained a reference sample with a recovery of 121%, exceeding the control limits of 80 to 100 percent. The laboratory was requested to re-analyze these batches. Recoveries were acceptable on the second run (see Section 6.9 of Volume II of this report) and the second set of data was used for the entire batch of samples.

Two types of reference soil samples were used: urban soil provided by University of Cincinnati (640, 3,132, and 6,090 ppm lead), and NIST SRM 2711 (Montana soil, 1,162 ppm lead). It is interesting, but not unexpected, that the average recovery of 89% for the NIST Montana soil was lower than the average of 105% for the urban soils. Lead in urban soils tends to be from more leachable sources[40] (i.e. paint, past automobile emissions, industrial facilities)

7.4.2 Laboratory Quality Control Samples

Each laboratory provided quality assurance procedures during the selection and qualification process. These approved procedures (outlined in the National Survey's Protocol and Sample Design Report, June, 1999) were adhered to for all study samples. In general, the laboratories performed instrumental and duplicate quality control analyses, as required by ASTM E 1613-94 and the American Industrial Hygiene Association's Environmental Lead Laboratory Accreditation Program (ELLAP) Quality Manual and Policies, to ensure that the original calibration solutions were accurate, the instruments were properly zeroed, instrumental drift was not excessive, and carryover between samples did not occur. These included duplicate injections of the same sample, method blanks, and spiked samples at a minimum frequency of five percent of the samples.

[40] Personal communication with Sandy Roda, Director, Hematology and Environmental Laboratory, University of Cincinnati.

7.4.3 Laboratory Selection Quality Assurance

The two laboratories used for analysis of dust and soil samples, respectively, were recognized by the EPA under its National Lead Laboratory Accreditation Program (NLLAP) for those analyses throughout the laboratory qualification and performance phases of the National Survey. This recognition provided assurance of the quality of laboratory performance of lead analyses and reporting. In addition, the laboratories were accredited by the American Industrial Hygiene Association; this accreditation provided a separate assurance of the quality of laboratory management and performance of environmental analyses and reporting.

APPENDIX A

Comparison of Findings on LBP Hazards with Respect to *de minimis* Hazards Under the HUD Lead Safe Housing Rule and the 1995 HUD *Guidelines*

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Comparison of Findings on LBP Hazards with Respect to *de minimis* Hazards Under the HUD Lead Safe Housing Rule and the 1995 HUD *Guidelines*

A.1 Introduction

When the National Survey was initiated, the 1995 HUD *Guidelines* were the main criteria for determining whether a LBP hazard was present in a home; these had been used by the EPA in issuing its interim LBP hazard guidance (60 *Federal Register* 47248, Sepember 11, 1995). By the time the survey was completed, HUD had issued a regulation that defined LBP hazard in a different manner than the *Guidelines*. Thus, two definitions of LBP hazard were used in the draft analysis and data presentation: the 1995 HUD *Guidelines* definition and the interim standards for *any* LBP hazard in the HUD Lead Safe Housing Rule (24 CFR 35).[36] Under both definitions, a home is said to have a LBP hazard if one or more of the following conditions prevails: LBP with deterioration above certain thresholds; floor dust lead loadings above certain thresholds; window sill dust lead loadings above certain thresholds; or soil lead concentrations above certain thresholds. In addition, under the *Guidelines* definition, elevated window trough dust lead loadings above certain thresholds can be a LBP hazard. The *Guidelines* thresholds are higher than the Lead Safe Housing Rule thresholds for deteriorated LBP, floor dust lead loadings, and window sill dust lead loadings; but lower for soil lead concentrations. Further, at the time of the initial data analyses, the play area soil data had not been collected; thus, these data are not included in the current discussion. However, since some readers may find this information to be of interest, this appendix presents a side-by-side summary of the key survey findings with respect to these two previous definitions of a LBP hazard.

Section 3.1 gives the definitions of LBP hazard under the 1995 HUD *Guidelines* and under the HUD Lead Safe Housing Rule[37].

[36] See Chapter 3 for a complete description of each of these definitions (Definitions II and III). Definition I for significant LBP hazard is used for findings presented throughout Volume I.

[37] The tabulations in this appendix on LBP hazards under the Lead Safe Housing Rule do not include play area soil lead hazards.

A.2 Prevalence of Lead-Based Paint Hazards in Housing

An estimated 31 million (±4 million) or 32 percent (±4%) of HUs in the United States have LBP hazards as defined by the HUD 1995 *Guidelines*, while 26 million (±3 million) or 27 percent (±3%) have LBP hazards as defined by the HUD Lead Safe Housing Rule. Tables A.1a and A.1b present the number and percentage of housing units with LBP hazards by selected characteristics, according to the two definitions of LBP hazard.

Homes in Northeastern and Midwestern states are more likely to have LBP hazards than homes in Southern or Western states. An estimated 49 percent (*Guidelines*) and 44 percent (Lead Safe Housing Rule) of homes in the Northeast have LBP hazards, while the estimates are 26 percent (*Guidelines*) (18 percent under the Lead Safe Housing Rule) and 21 (16)[38] percent for homes in the South and West, respectively. Older homes are more likely to have LBP hazards than newer homes. An estimated 17 (9) percent (±5%) of homes built between 1960 and 1977 have LBP hazards, but the percentage increases to 54 (45) percent (±10%) for homes built between 1940 and 1959, and to 73 (73) percent (±10%) for homes built before 1940. Similar results were found for homes with children under age 6 by age of construction.

An estimated 4.6 million (± 1.3 million) homes, or 28 percent (± 8 percent) of all homes with children under age 6, have LBP hazards, as defined by HUD 1995 *Guidelines*. An estimated 4.3 million homes (± 1.3 million), or 26 percent (± 7 percent) of all homes with children under age 6, have LBP hazards, as defined by HUD Lead Safe Housing Rule. An estimated 1.2 million (± 0.6 million) homes with household incomes under $30,000 and resident children under age 6 have LBP hazards (1995 *Guidelines*), representing 24 percent (± 12%) of all such homes. Under the HUD Lead Safe Housing Rule definition, this estimate is 1.2 (± 0.6) million homes (25% ± 12%).

More homes with lower income occupants have LBP hazards than homes where occupants have higher incomes. Under the *Guidelines*, an estimated 41 (36) percent of households with less than $30,000/year income have LBP hazards, compared with 27 (26) percent of households in the $30,000/year or above income level. More renter-occupied housing has LBP hazards than does owner-occupied housing. An estimated 44 (32) percent of renter-occupied housing has LBP hazards, while only 27 (25) percent of owner-occupied housing has LBP hazards.

[38] Here, and in the sequel, the first number or percentage is the estimate under the *Guidelines* definition of lead-based paint hazard, while the second number is the estimate under the Lead Safe Housing Rule definition.

Table A.1a Prevalence of Housing Units with Lead-Based Paint (LBP) Hazards, as defined by HUD 1995 *Guidelines*, by Selected Characteristics

Characteristic	All HUs (000)[2]	HUD 1995 *Guidelines*: LBP Hazards[1] Number of HUs with LBP Hazards (000)			Percent of HUs with LBP Hazards (%)[3]			HUs in Sample
		Estimate	Lower 95% CI[4]	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Total Occupied Housing Units	95,688	31,001	27,155	34,847	32%	28%	37%	831
Region:								
Northeast	19,290	9,503	6,687	12,318	49%	35%	63%	155
Midwest	22,083	8,507	7,100	9,913	39%	31%	46%	196
South	35,474	9,090	7,549	10,632	26%	21%	30%	277
West	18,841	3,901	2,875	4,927	21%	15%	27%	203
Construction Year:								
1978-1998	29,774	2,479	1,227	3,732	8%	4%	13%	220
1960-1977	27,874	4,688	3,290	6,087	17%	11%	22%	267
1940-1959	20,564	11,113	9,304	12,923	54%	46%	62%	186
Before 1940	17,476	12,720	11,310	14,129	73%	66%	80%	158
One or More Children Under Age 6:								
All HU ages	16,402	4,634	3,397	5,871	28%	21%	36%	184
HUs built 1978-1998	5,847	242	0	527	4%	0%	9%	56
HUs built 1960-1977	5,098	487	173	802	10%	3%	16%	61
HUs built 1940-1959	3,055	1,940	1,205	2,674	64%	39%	88%	40
HUs built before 1940	2,401	1,965	1,161	2,770	82%	40%	100%	27
Housing Unit Type:								
Single family	82,651	26,836	23,616	30,055	32%	28%	37%	705
Multi-family	13,037	4,165	2,614	5,717	32%	22%	42%	126
Occupant Status:								
Owner-occupied	66,232	18,170	15,846	20,494	27%	24%	31%	539
Renter-occupied	29,074	12,765	9,260	16,270	44%	34%	54%	289
Refusal/Don't Know[5]	381							3
Income:								
Less than $30,000/year	33,830	13,767	10,457	17,077	41%	32%	49%	309
Equal to or more than $30,000/year	56,111	15,226	12,829	9,260	27%	23%	31%	482
Refusal/Don't Know	5,747							40
One or More Children Under Age 6								
All Income Categories	16,402	4,634	3,397	5,871	28%	21%	36%	184
Less than $30,000/year	4,791	1,161	576	1,747	24%	12%	36%	61
Equal to or more than $30,000/year	11,236	3,378	2,346	4,410	30%	21%	39%	117
Refusal/Don't Know	375							6
Government Support:								
Government support	4,809	1,191	293	2,088	25%	8%	42%	54
No government support	86,070	28,352	24,088	32,616	33%	28%	38%	733
Refusal/Don't Know	4,809							44

Table A.1a Prevalence of Housing Units with Lead-Based Paint (LBP) Hazards, as Defined by HUD 1995 *Guidelines*, by Selected Characteristics (continued)

Characteristic	All HUs (000)[2]	HUD 1995 *Guidelines*: LBP Hazards[1] Number of HUs with LBP Hazards (000)			Percent of HUs with LBP Hazards (%)[3]			HUs in Sample
		Estimate	Lower 95% CI[4]	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Poverty:								
In Poverty	13,221	5,472	3,520	7,423	41%	30%	53%	137
Not in Poverty	76,336	22,538	18,397	26,679	30%	24%	35%	651
Refusal/Don't Know	6,130							43
Race								
White	77,005	24,601	20,942	28,261	32%	27%	37%	622
Other[6]	16,937	5,953	4,022	7,885	35%	26%	45%	193
Refusal/Don't Know	1,746				26%			16
Ethnicity:								
Hispanic/Latino	7,434	2,535	1,291	3,778	34%	21%	48%	86
Not Hispanic/Latino	87,008	27,854	23,830	31,877	32%	27%	37%	736
Refusal/Don't Know	1,246							9

[1] LBP hazard as defined in text and HUD 1995 *Guidelines* .

[2] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[3] All percentages are calculated with the "All HUs" column in each row used as the denominator.

[4] CI = 95% confidence interval for the estimated number or percent.

[5] Refusals and "don't know" responses by survey respondents.

[6] "Other" race includes African American, Asian, American Indian or Alaskan Native, Native Hawaiian or other Pacific Islander, and more than one race.

Table A.1b Prevalence of Housing Units with Lead-Based Paint (LBP) Hazards, as Defined by HUD Lead Safe Housing Rule, by Selected Characteristics

Characteristic	All HUs (000)[2]	HUD Lead Safe Housing Rule: LBP Hazards[1] Number of HUs with LBP Hazards (000)			Percent of HUs with LBP Hazards (%)[3]			HUs in Sample
		Estimate	Lower 95% CI[4]	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Total Occupied Housing Units	95,688	25,501	22,767	28,235	27%	24%	30%	831
Region:								
Northeast	19,290	8,455	6,475	10,435	44%	34%	54%	155
Midwest	22,083	7,540	6,675	8,405	34%	30%	38%	196
South	35,474	6,514	5,226	7,803	18%	15%	22%	277
West	18,841	2,992	2,097	3,886	16%	11%	21%	203
Construction year:								
1978-1998	29,774	1,098	215	1,981	4%	1%	7%	220
1960-1977	27,874	2,509	1,543	3,475	9%	6%	12%	267
1940-1959	20,564	9,203	7,100	11,306	45%	35%	55%	186
Before 1940	17,476	12,691	10,898	14,484	73%	62%	83%	158
One or More Children Under Age 6:								
All HU ages	16,402	4,275	3,056	5,494	26%	19%	33%	184
HUs built 1978-1998	5,847	56	0	165	1%	0%	3%	56
HUs built 1960-1977	5,098	531	47	1,016	10%	1%	20%	61
HUs built 1940-1959	3,055	1,651	1,008	2,295	54%	33%	75%	40
HUs built before 1940	2,401	2,036	1,249	2,824	85%	50%	100%	27
Housing Unit Type:								
Single family	82,651	22,646	20,114	25,178	27%	24%	30%	705
Multi-family	13,037	2,855	1,548	4,162	22%	12%	32%	126
Occupant Status:								
Owner-occupied	66,232	16,275	14,147	18,402	25%	21%	28%	539
Renter-occupied	29,074	9,226	7,030	11,422	32%	24%	39%	289
Refusal/Don't Know[5]	381							3
Household Income:								
Less than $30,000/year	33,830	12,082	9,067	15,096	36%	27%	45%	309
Equal to or more than $30,000/year	56,111	11,865	9,732	13,998	21%	17%	25%	482
Refusal/Don't Know	5,747							40
One or More Children Under Age 6:								
All Income Categories	16,402	4,275	3,056	5,494	26%	19%	33%	184
Less than $30,000/year	4,791	1,176	570	1,782	25%	12%	37%	61
Equal to or more than $30,000/year	11,236	3,005	1,896	4,114	27%	17$	37%	117
Refusal/Don't Know	375							6
Government Support:								
Government support	4,809	1,366	289	2,442	28%	6%	51%	54
No government support	86,070	23,192	20,297	26,087	27%	24%	30%	733
Refusal/Don't Know	4,809							44

Table A.1b Prevalence of Housing Units with Lead-Based Paint (LBP) Hazards, as Defined by HUD Lead Safe Housing Rule, by Selected Characteristics (continued)

HUD Lead Safe Housing Rule: LBP Hazards [1]								
Characteristic	**All HUs (000)[2]**	**Number of HUs with LBP Hazards (000)**			**Percent of HUs with LBP Hazards (%)[3]**			**HUs in Sample**
		Estimate	**Lower 95% CI[4]**	**Upper 95% CI**	**Estimate**	**Lower 95% CI**	**Upper 95% CI**	
Poverty:								
In Poverty	13,221	4,935	3,274	6,596	37%	25%	50%	137
Not in Poverty	76,336	18,092	15,270	20,914	24%	20%	27%	651
Refusal/Don't Know	6,130							43
Race:								
White	77,005	20,457	17,790	23,124	27%	23%	30%	622
Other[6]	16,937	4,572	3,136	6,008	27%	19%	35%	193
Refusal/Don't Know	1,746				27%			16
Ethnicity:								
Hispanic/Latino	7,434	2,681	1,486	3,876	36%	20%	52%	86
Not Hispanic/Latino	87,008	22,433	19,873	24,993	26%	23%	29%	736
Refusal/Don't Know	1,246							9

[1] LBP hazard as defined in text and HUD Lead Safe Housing Rule.

[2] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[3] All percentages are calculated with the "All HUs" column in each row used as the denominator.

[4] CI = 95% confidence interval for the estimated number or percent.

[5] Refusals and "don't know" responses by survey respondents.

[6] "Other" race includes African American, Asian, American Indian or Alaskan Native, Native Hawaiian or other Pacific Islander, and more than one race.

The differences among LBP prevalence by urbanization, single family versus multi-family housing, poverty, ethnicity, and race are not significant in that the confidence intervals overlap.

Table A.2 presents the number of homes with LBP by location in the building–either interior or exterior, or both. Approximately one-half of the homes with LBP hazards have the hazard on the interior only–18 (12) percent of all homes, but 55 (44) percent of homes with LBP hazards.

Table A.3 presents data for the presence of LBP hazards in homes by type of hazard, for all homes and for homes with one or more children under the age of 6 years, and for both definitions of hazard. The percentages in the upper line of each row of Table A.3 show the percent of all HUs with the type of LBP hazard, while the percentages in the lower line of each row of Table A.3 show the percent of all HUs with a child under age 6 with that type of LBP hazard.

Under the 1995 *Guidelines* definition, the number of homes with LBP hazards is dominated by homes with lead dust hazards. Of the 31 million homes with LBP hazards (under the *Guidelines*), an estimated 24 million have dust lead hazards, 16 million have deteriorated LBP, and 2 million have soil lead hazards.[39] The pattern is somewhat different under the HUD Lead Safe Housing Rule, reflecting the different thresholds for deteriorated LBP and dust lead hazards. Of the 26 million homes with LBP hazards (under the Lead Safe Housing Rule), an estimated 15 million have dust lead hazards, 17 million have deteriorated LBP, and 2 million have soil lead hazards.

Table A.2 Prevalence of Lead-Based Paint (LBP) Hazards by Location in the Building

HUD 1995 *Guidelines*: LBP Hazard							
LBP Hazard Location	**Number of HUs[1] (000)**			**Percent of HUs[2]**			**HUs in Sample**
	Estimate	**Lower 95% CI[3]**	**Upper 95% CI**	**Percent**	**Lower 95% CI**	**Upper 95% CI**	
Interior only	16,961	13,717	20,205	18%	14%	21%	152
Both Interior and Exterior	9,459	6,845	12,073	10%	7%	13%	82
Exterior only	4,581	2,913	6,249	5%	3%	7%	43
Anywhere	31,001	26,502	35,500	32%	28%	37%	277
No LBP Hazard	64,687	60,188	69,186	68%	63%	72%	554
Total HUs	95,688			100%			831
HUD Lead Safe Housing Rule: LBP Hazard							
LBP Hazard Location	**Number of HUs (000)**			**Percent of HUs**			**HUs in Sample**
	Estimate	**Lower 95% CI**	**Upper 95% CI**	**Percent**	**Lower 95% CI**	**Upper 95% CI**	
Interior only	11,329	8,834	13,824	12%	9%	14%	101
Both Interior and Exterior	8,537	6,577	10,498	9%	7%	11%	81
Exterior only	5,635	3,828	7,442	6%	4%	8%	48
Anywhere	25,501	22,719	28,284	27%	24%	30%	230
No LBP Hazard	70,187	67,404	72,969	73%	70%	76%	601
Total HUs	95,688			100%			831

[1] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[2] All percentages are calculated with total housing units (95,688) as the denominator. Percentages may not total 100% due to rounding.

[3] CI = 95% confidence interval for the estimated number or percent.

[39] The estimates for the three types of LBP hazard do not add to the total number of homes with LBP hazards because some homes have two or all three of the three types of hazards.

Table A.3 Prevalence of Lead-Based Paint (LBP) Hazards in Housing Units with a Child Under 6 Years of Age by Type of Hazard

HUD 1995 *Guidelines*						
Type of Hazard	**Number of HUs (000)[1]**			**Percent of HUs (%)[2]**		
	Estimate	**Lower 95% CI[3]**	**Upper 95% CI**	**Estimate**	**Lower 95% CI**	**Upper 95% CI**
Deteriorated Lead Based Paint						
All HUs	15,659	13,444	17,874	16%	14%	19%
HUs w/ Child Under 6	2,707	1,883	3,531	17%	11%	22%
Interior Lead Dust						
All HUs	23,899	19,197	28,600	25%	20%	30%
HUs w/ Child Under 6	3,467	2,217	4,717	21%	14%	29%
Lead Contaminated Soil						
All HUs	2,435	1,150	3,719	3%	1%	4%
HUs w/ Child Under 6	644	106	1,181	4%	1%	7%
Any LBP Hazard						
All HUs	31,001	27,155	34,847	32%	28%	37%
HUs w/ Child Under 6	4,634	3,397	5,871	28%	21%	36%
HUD Lead Safe Housing Rule						
Type of Hazard	**Number of HUs (000)**			**Percent of HUs (%)**		
	Estimate	**Lower 95% CI**	**Upper 95% CI**	**Estimate**	**Lower 95% CI**	**Upper 95% CI**
Deteriorated Lead Based Paint						
All HUs	17,098	14,778	19,417	18%	15%	20%
HUs w/ Child Under 6	3,045	2,106	3,985	19%	13%	24%
Interior Lead Dust						
All HUs	15,021	12,424	17,617	16%	13%	18%
HUs w/ Child Under 6	2,551	1,515	3,587	16%	9%	22%
Lead Contaminated Soil						
All HUs	1,559	209	2,910	2%	0%	3%
HUs w/ Child Under 6	476	0	996	3%	0%	6%
Any LBP Hazard						
All HUs	25,501	22,767	28,235	27%	24%	30%
HUs w/ Child Under 6	4,275	3,056	5,494	26%	19%	33%

[1] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[2] Percentages are calculated with total housing units (95,688) or with housing units with a child under age 6 (16,402) as the denominator, or as applicable.

[3] CI = 95% confidence interval for the estimated number or percent.

A.3 Prevalence of Deteriorated Lead-Based Paint

Although there are many homes with LBP, the condition of the paint is important in determining whether a hazard exists. Except during renovations and certain other disturbances, intact paint is believed to pose little immediate risk to occupants. However, deteriorated paint may present an immediate danger to occupants, especially to young children.

Table A.4 presents the number and percentage of HUs with deteriorated LBP by location in the building - either interior or exterior, or both. Estimates are provided for two definitions of deteriorated LBP hazard, as follows:

1. HUD 1995 *Guidelines* – A LBP hazard is defined as LBP in poor condition. Poor condition is defined as damage to more than 10 square feet (exterior) or 2 square feet (interior) of lead-based paint on large surface area components (walls, doors) or damage to more than 10% of the total surface area of small surface area components (window sills, baseboards, trim).

2. The HUD Lead Safe Housing Rule – This rule defines a LBP hazard when LBP exhibits any deterioration, no matter how small the area of damage.

Table A.4 Prevalence of Deteriorated Lead-Based Paint (LBP) by Location in the Building

Deteriorated Paint per 1995 *Guidelines*							
All Construction Years	**Number of HUs[1] with Deteriorated LBP (000)**			**Percent[2] of HUs with Deteriorated LBP(%)**			**HUs in Sample**
	Estimate	**Lower 95% CI[3]**	**Upper 95% CI**	**Estimate**	**Lower 95% CI**	**Upper 95% CI**	
Interior Only	3,251	2,127	4,374	3%	2%	5%	31
Both Interior and Exterior	4,407	2,999	5,815	5%	3%	6%	44
Exterior Only	8,329	6,185	10,473	9%	6%	11%	72
No Deteriorated LBP	79,701	77,265	82,137	83%	81%	86%	684
TOTAL	95,688			100%			831
Post-1977 Construction Year							
Interior Only				0%	0%	0%[4]	0
Both Interior and Exterior				0%	0%	0%[4]	0
Exterior Only	83	0	240	0%	0%	1%	1
No Deteriorated LBP	29,692	28,741	30,643	100%	97%	100%	219
TOTAL	29,774			100%			220
Deteriorated Paint per HUD Lead Safe Housing Rule							
All Construction Years	**Number of HUs with Deteriorated LBP (000)**			**Percent of HUs with Deteriorated LBP(%)**			**HUs in Sample**
	Estimate	**Lower 95% CI**	**Upper 95% CI**	**Estimate**	**Lower 95% CI**	**Upper 95% CI**	
Interior Only	4,180	2,851	5,509	4%	3%	6%	39
Both Interior and Exterior	6,236	4,661	7,811	7%	5%	8%	62
Exterior Only	7,009	4,922	9,097	7%	5%	10%	61
No Deteriorated LBP	78,263	75,953	80,572	82%	79%	84%	669
TOTAL	95,688			100%			831
Post-1977 Construction Year							
Interior Only				0%	0%	0%[4]	0
Both Interior and Exterior	56	0	165	0%	0%	0%[4]	1
Exterior Only	83	0	240	0%	0%	1%	1
No Deteriorated LBP	29,636	28,677	30,595	100%	96%	100%	218
TOTAL	29,775			100%			220

[1] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[2] Percentages are calculated with total housing units (95,688) as the denominator, or total post-1977 housing units (29,775), as applicable. Percentages may not total 100% due to rounding.

[3] CI = 95% confidence interval for the estimated number or percent.

[4] When there are no observed HUs, the statistical estimate has no variability, and thus the upper end of the confidence interval is reported as 0%. It is, of course, possible that some HUs with the characteristic exist. Thus, upper confidence limits of 0% should be interpreted as "less than 0.5%."

Using the HUD 1995 *Guidelines* definition, an estimated 16 million (±2 million) or 17 percent (±2%) of housing units in the United States have deteriorated LBP. Roughly one-third of these homes

have deterioration on both interior and exterior surfaces. The deteriorated LBP is only on the exterior for approximately one-half of the homes with deteriorated LBP.

Using the HUD Lead Safe Housing Rule definition, an estimated 17 million (±2 million) or 18 percent (±3%) of housing units in the United States have deteriorated LBP. Roughly 40 percent of these homes have deterioration on both interior and exterior surfaces. The deteriorated LBP is only on the exterior for approximately 40 percent of the homes with deteriorated LBP.

Table A.5a presents the number and percentage of housing units with deteriorated LBP (HUD 1995 *Guidelines*) by construction year. The data suggest that older homes are more likely to have deteriorated LBP than newer homes. An estimated 3% of homes built between 1960 and 1977 have deteriorated LBP, but the percentage increases to 30% for homes built between 1940 and 1959, and to 51% for homes built before 1940. No significant differences were found when this was crossed with urbanization category.

Table A.5b shows the percent of homes with deteriorated paint that have deteriorated LBP. While for most homes (80 percent) built before 1940, their deteriorated paint is LBP, this is only true for half of the homes built between 1940 and 1959, and for practically none of homes built since 1960.

Table A.5a Distribution of Housing Units (HUs) with Deteriorated Lead-Based Paint (LBP) and Deteriorated Paint by Construction Year

HUD 1995 *Guidelines*: LBP in Poor Condition							
Construction Year		**Number of HUs with Deteriorated LBP (000)**			**Percent of HUs with Deteriorated LBP (%)[1]**		
	Total HUs (000)[2]	**Estimate**	**Lower 95% CI[3]**	**Upper 95% CI**	**Estimate**	**Lower 95% CI**	**Upper 95% CI**
1978-1998	29,774	83	0	240	0%	0%	1%
1960-1977	27,874	848	207	1,489	3%	1%	5%
1940-1959	20,564	6,216	4,329	8,102	30%	21%	39%
Before 1940	17,476	8,841	7,099	10,582	51%	42%	60%
Total HUs	95,688	15,987	13,868	18,105	17%	15%	19%

Table A.5b Distribution of Housing Units (HUs) with Deteriorated Lead-Based Paint (LBP) and Deteriorated Paint by Construction Year (continued)

HUD 1995 *Guidelines*: Paint in Poor Condition							
Construction Year	Total HUs with Deteriorated Paint (000)[2]	Number of HUs with Deteriorated LBP (000)			Percent of HUs with Deteriorated Paint that is Deteriorated LBP (%)[1]		
		Estimate	Lower 95% CI[3]	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI
1978-1998	3,979	83	0	240	2%	0%	6%
1960-1977	7,503	848	207	1,489	11%	3%	20%
1940-1959	11,348	6,216	4,229	7,917	55%	38%	71%
Before 1940	11,070	8,841	6,796	10,247	80%	64%	96%

[1] Percentages may not total 100% due to rounding.
[2] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.
[3] CI = 95% confidence interval for the estimated number or percent.

A.4 Prevalence of Dust Lead in Housing

Table A.6 presents the prevalence of all homes and homes with one or more children under 6 years of age with a dust lead hazard somewhere in the home,[40] as defined by HUD 1995 *Guidelines* and the HUD Lead Safe Housing Rule. The HUD 1995 *Guidelines* considered lead in dust to be a hazard when dust on floors had greater than 100 µg/ft^2 lead, dust on window sills had greater than 500 µg/ft^2 lead, or dust on window troughs had greater than 800 µg/ft^2 lead. The new HUD Lead Safe Housing Rule, defines a dust lead hazard as greater than or equal to 40 µg/ft^2 lead on floors or 250 µg/ft^2 lead on window sills. There is no longer a hazard level defined for dust lead on window troughs.

Using the HUD 1995 *Guidelines* of dust lead hazard, an estimated 25 percent (±5%) of all homes have dust lead hazard somewhere in the home, while 4 percent (±2%) of all homes, nearly 3.5 million homes, have both a child under 6 years of age and a dust lead hazard.

Using the HUD Lead Safe Housing Rule definition, slightly fewer homes have dust lead hazards. An estimated 16 percent (±2%) of all homes have a dust hazard somewhere in the home, and 3 percent (±1%) of all homes have both a child under 6 years of age and a dust lead hazard. While it might

[40] The maximum lead dust loading on any surface tested (floor, window sill, and window trough) in the home was used to determine whether a dust lead hazard existed.

be expected that the number of homes with dust lead hazards would be greater under the new HUD Lead Safe Housing Rule because of the lower floor and sill dust lead standards, the deletion of trough dust lead from the definition may explain the lower number of homes with dust lead hazards, as will be seen.

Table A.6 Prevalence of Housing Units with a Dust Lead Hazard Somewhere in the Home

HU Category[1]	Number of HUs (000)			Percent of HUs(%)[2]		
	Estimate	Lower 95% CI[3]	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI
HUD 1995 *Guidelines*:						
HUs with Lead Dust Hazard	23,899	19,197	28,600	25%	20%	30%
HUs with children under 6 years and Lead Dust Hazard	3,467	2,217	4,717	21%	14%	29%
HUD Lead Safe Housing Rule:						
HUs with Lead Dust Hazard	15,021	12,424	17,617	16%	13%	18%
HUs with children under 6 years and Lead Dust Hazard	2,551	1,515	3,587	16%	9%	22%

[1] "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

[2] All percentages are calculated with total housing units (95,688) or HUs with resident children under age 6 (16,402) as the denominator.

[3] CI = 95% confidence interval for the estimated number or percent.

A.5 Association between Dust Lead Hazards and LBP Paint Condition

Table A.7 presents the prevalence of dust lead hazards in relation to the condition of the interior LBP. Dust lead hazards are more likely to exist in homes with deteriorated LBP. An estimated 72 percent of homes with deteriorated LBP (1995 *Guidelines*) have lead dust hazards, while only 42 percent of homes with LBP in good or fair condition have lead dust hazards. Only 15 percent of homes with no interior LBP have lead dust hazards. Although it appears from the data that the presence of LBP, especially deteriorated LBP, contributes to higher dust lead hazard, there are additional sources of lead in the environment to account for dust lead in homes with no lead-based paint. Table A.7 allows one to compare the relative risks (with 95 percent confidence intervals on that risk) of interior lead dust hazards associated with different paint conditions. The presence of deteriorated LBP makes a house 1.7 ($\pm$0.5) times as likely to have an interior lead dust hazard compared to a house where the LBP is in good condition, and 4.9 ($\pm$1.9) times as likely as a house without LBP. Even a house with LBP in good condition is 2.8 ($\pm$0.8) times as likely to have interior lead dust hazards as one without any LBP.

Table A.7 Association Between Dust Lead Hazards and Presence and Condition of Interior Lead-based Paint

		No Interior LBP		Interior LBP in Good Condition		Deteriorated Interior LBP	
All HU Ages: 1995 *Guidelines*							
No Interior Dust Lead Hazards	Estimate[1]	56,980	60%	12,288	13%	2,155	2%
	Lower 95% CI[2]	53,448	56%	9,215	10%	1,287	1%
	Upper 95% CI	60,512	63%	15,361	16%	3,024	3%
Interior Dust Lead Hazards	Estimate	9,840	10%	8,922	9%	5,503	6%
	Lower 95% CI	6,733	7%	6,156	6%	3,740	4%
	Upper 95% CI	12,946	14%	11,689	12%	7,265	8%
Total HUs	95,688						
Post-1977 Construction: 1995 *Guidelines*							
		No Interior LBP		**Interior LBP in Good Condition**		**Deteriorated Interior LBP**	
No Interior Dust Lead Hazards	Estimate	26,363	89%	1,014	3%	0	0%
	Lower 95% CI	24,522	82%	183	1%	0	0%
	Upper 95% CI	28,205	95%	1,845	6%	0	0%
Interior Dust Lead Hazards	Estimate	2,214	7%	183	1%	0	0%
	Lower 95% CI	1,012	3%	0	0%	0	0%
	Upper 95% CI	3,417	11%	545	2%	0	0%
Total HUs	29,774						
All HU Ages: HUD Lead Safe Housing Rule							
		No Interior LBP		**Interior LBP in Good Condition**		**Deteriorated Interior LBP**	
No Interior Dust Lead Hazards	Number HUs	62,752	66%	13,070	14%	4,563	5%
	Lower 95% CI	60,141	63%	10,461	11%	2,956	3%
	Upper 95% CI	65,363	68%	15,679	16%	6,170	6%
Interior Dust Lead Hazards	Number HUs	4,068	4%	5,382	6%	5,853	6%
	Lower 95% CI	2,584	3%	3,414	4%	4,433	5%
	Upper 95% CI	5,552	6%	7,350	8%	7,273	8%
Total HUs	95,688						
Post-1977 Construction: HUD Lead Safe Housing Rule							
		No Interior LBP		**Interior LBP in Good Condition**		**Deteriorated Interior LBP**	
No Interior Dust Lead Hazards	Number HUs	27,801	93%	958	3%	56	0%
	Lower 95% CI	26,162	88%	144	0%	0	0%
	Upper 95% CI	29,440	99%	1,771	6%	165	1%
Interior Dust Lead Hazards	Number HUs	777	3%	183	1%	0	0%

	Lower 95% CI	0	0%	0	0%	0	0%
	Upper 95% CI	1,572	5%	545	2%	0	0%
Total HUs	29,774						

[1] Estimate is either the number of permanently occupied, noninstitutional housing units (000) in which children are permitted to live, or the percentage of total housing units (95,688 or 29,774).

[2] CI = 95% confidence interval for the estimated number or percent.

APPENDIX B

Comparison of Protocols for the HUD 1990 Survey of Lead-Based Paint (LBP) in Housing and the HUD National Survey of Lead and Allergens in Housing

Comparison of Protocols for the HUD 1990 Survey of Lead-Based Paint (LBP) in Housing and the HUD National Survey of Lead and Allergens in Housing

Area	HUD National Survey of Lead-Based Paint in Housing	HUD National Survey of Lea Allergens in Housing
Types/numbers of housing units selected for the survey and whose data were available to the TSCA Section 403 risk analysis	284 housing units selected from occupied, permanent, non-institutional housing in the 48 coterminous states built prior to 1980 and having the potential for containing children. (These units were all privately-owned. While publicly-owned units were also selected for the survey, data for these units are not considered in this summary.)	831 housing units selected in a t stage stratified random sample f occupied, permanent, non-institutionalized housing having potential for containing children primary sampling units (PSUs).
Breakdown of selected units by year built	Pre-1940: 27% 1940-1959: 31% 1960-1979: 42% Post-1979: 0%	Pre-1940: 18% 1940-1959: 22% 1960-1977: 29% Post-1977: 31%
Dates of environmental sampling	November 1989 to March 1990	August 1998 to February 1999, a July to August 1999
Selecting rooms for environmental sampling	Telephone household interview provided information on rooms. One room was selected for sampling in each of the following strata: ■ Wet room -- rooms containing plumbing (e.g., kitchen, bathroom, laundry room, utility room) ■ Dry room -- all rooms not classified as wet rooms ■ Main entryway (floor dust samples only)	Room Inventory Form from the Screening/Recruiting Questionn used to obtain information on ro One room was randomly selecte sampling in each of the followin strata: ■ Kitchen ■ Common living area (e.g., liv room, den, family room) ■ Bedroom in which one or m children aged 17 years or y regularly slept, or any regul occupied bedroom if no suc children lived in the unit (occasionally, two such bed were selected) ■ Other random room among remaining rooms in the hou (Note: Two rooms were ran selected from this stratum if stratum contained at least si ■ Main entry (floor dust only ■ Interior common area (multi-dwellings, floor dust only)
Method of assigning sampling weights	Weights reflect the various stages of sampling. Total of the sampling weights equaled the estimated number of housing units	Weights reflect the various stag sampling. Total of the sampling within a given census region eq

Area	HUD National Survey of Lead-Based Paint in Housing	HUD National Survey of Lea Allergens in Housing
	with children under age 7 years (13,912,000, as estimated by the 1987 AHS). Total of the sampling weights within a given census region equaled the estimated number of units with children under age 7 years in the census region.	estimated number of units in the region.
Method for taking dust samples for lead analysis	Blue Nozzle vacuum (a few wipe samples were also collected). *Sampling house dust for lead: basic concepts and literature review.* (1995). EPA 747-R-95-007.	Wipes, collected in accordance v ASTM E1728-95, *Practice for the determination of settled dust sample using wipe sampling methods for le determination by atomic absorption spectrometry techniques.*
Number and location of floor-dust samples per room	One sample from each selected room (location not dictated in the protocol)	One sample from each selected r generally taken from the center largest open area of the room.
Window sill/trough dust sampling approach	A window was selected within each selected room according to a ranking scheme. Sampling was performed from both the sill and trough of the selected window until enough dust was collected or until the entire sill or trough was vacuumed.	Entire sill and trough sampled fr random window in the selected r Trough definition included slide
Number and location of sill and trough dust samples per room	One sample from the sill and one sample from the trough of the selected window in the selected wet room and dry room	One sample from the sill and one from the trough of the selected v each selected room
Method of analyzing dust samples	Graphite Furnace Atomic Absorption Spectroscopy (GFAA) (with EPA SW-846 digestion method)	Flame Atomic Absorption Spect (FAAS) using NIOSH method 7(Digestion method: modification SW-846 Method 3050 or ASTM (hot-plate digestions utilizing nit and/or perchloric acid and/or hy peroxide). Method same as used proficiency testing within the Environmental Lead Laboratory Accreditation Program (ELLAP).
Soil sampling approach	One composite sample of up to 3 core samples (the latter two taken within 20 inches of the first), each taken at a depth of 10 cm, was collected at each of the following locations: entryway, drip-line, and remote area (i.e., an area halfway between the unit and its property boundary, or within 25 feet of the unit, whichever was less).	Two sides of the unit were selec soil sampling: the side containin major entryway (Wall 1) and a s randomly-selected side (Wall 2). were collected from the top 0.5 i soil at the following three sites: ■ Main entry - a single sampl Wall 1 ■ Foundation/drip-line - one s

Area	HUD National Survey of Lead-Based Paint in Housing	HUD National Survey of Lea Allergens in Housing
		from each of Walls 1 and 2, sample being a composite o subsamples taken within 3 f foundation ■ Mid-yard area - one sample each of Walls 1 and 2, each being a composite of 3 core subsamples taken midway b the drip-line and boundary housing unit property. ■ Play Area – one composite s from bare soil under each u fixed play equipment. Soil samples were collected in a with core sampling procedures l ASTM E1727-95 (described in th *Guidelines* and in EPA's *Resider Sampling for Lead: Protocols for L Dust and Soil Sampling*). Sampl collected from bare soil when po no bare soil existed, samples wer collected from covered surfaces possible.
Method of analyzing soil samples	ICP-AES (with SW-846 digestion method)	ICP-AES using NIOSH method 7 Digestion method: modification 846 Method 3050 or ASTM ES 3 plate digestions utilizing nitric a and/or perchloric acid). Method used in proficiency testing withi Environmental Lead Laboratory Accreditation Program (ELLAP).
Handling dust-lead and soil-lead measurements below the detection limit	As log-transformed lead amounts are reported in the database, only positive measurements are represented. No indication is given as to when data may have been truncated due to being below detection limits.	The final results as reported by instrument are recorded in the d (i.e., not-detected results are not censored), along with detection
Method for taking paint-lead measurements	Spectrum analyzer XRF instrument (single 60-second spectrum reading measurement using a 40 millicurie cobalt source). Measurements were adjusted to statistically correct for measurement bias.	Spectrum analyzer XRF analyzer period readings with a 20-secon minimum in accordance with the applicable HUD-approved Perfo Characteristic Sheet .)
Approach to selecting <u>interior</u> painted components for paint-lead	Painted surfaces were categorized into the following four strata: ■ Walls/ceilings/floors	The following painted compone measured for lead in each selecte

Area	HUD National Survey of Lead-Based Paint in Housing	HUD National Survey of Lea Allergens in Housing
measurements	■ Metal substrate ■ Non-metal substrate ■ Other surfaces Five painted components were selected randomly for testing in each of the selected wet and dry rooms, one from each stratum along with a fifth selected randomly from among all strata. In addition, up to two purposive measurements were taken from paint anywhere in the unit that may be suspected to contain lead.	■ All four major walls ■ Ceiling ■ Door of major entryway ■ Window selected for dust s ■ Baseboard ■ Floor ■ Up to two other painted sur Technician choice based or containing deteriorated pai friction areas.
Approach to selecting exterior painted components for paint-lead measurements	Painted surfaces were categorized into the following four strata: ■ Wall (randomly-selected) ■ Metal substrate within the selected wall ■ Non-metal substrate within the selected wall ■ Other surfaces within the selected wall Five painted components were selected randomly for testing from the side of the unit containing the selected wall, one from each stratum along with a fifth selected randomly from among all strata. In addition, up to two purposive measurements were taken from paint anywhere on the exterior of the unit that may be suspected to contain lead.	Painted siding was measured for levels on each exterior wall. In a the following painted componen measured for lead on a random w ■ Miscellaneous trim (2 meas ■ Window ■ Door of major entryway – w independent. ■ Porch and railing – wall ind ■ Up to two other painted sur